PRODUCT ENGINEERING

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Factors of Safety Are Poor Substitutes for Ignorance

Reminiscent of the discourses of the philosophers of old whose favorite topic was an argument as to the number of angels that could stand on the point of a pin, one still hears ponderous discussions about the "factor of safety." Shall it be based on the yield point of the material or upon the ultimate strength? Shall the choice be the real or the apparent factor of safety? Even the latest textbooks and handbooks devote considerable space to discussing it and presenting tables for its selection.

Some years ago several designers pointed out that the factor of safety was really a factor of ignorance. With a big enough factor even a college sophomore could design a machine that would never fail. It might be ten times too big —but just consider the wonderful "factor of safety." Nor does a large factor of safety imply a wide margin of actual safety.

In blissful ignorance of such things as stress concentration, fatigue failure, the divergence between the assumed and actual physical properties of the materials used, and numerous other factors, engineers of previous generations cut the Gordian knot by the simple expedient of applying a "factor of safety." Experience established the empirical values of this factor and carried them safely across the uncharted seas of unknown variables. It made smooth sailing.

Today factual data are available from which these previously unknown quantities can readily be established. The uniform quality of the materials of construction, the accurate control of heat-treatments and all other production processes have practically eliminated the previously unknown variables. A much wider knowledge of stress calculations and the elaborate methods now available for determining actual loads makes it possible to design machine elements wherein the actual stress will closely approach the stress as calculated.

More recently it has been proposed to substitute the term factor of utilization in place of the term factor of safety. This is a more logical view of this question. It can readily be understood that the higher the factor of utilization, expressed as a percentage of the yield strength or ultimate strength of the material, as the case may be, the more exact must be the design calculations.

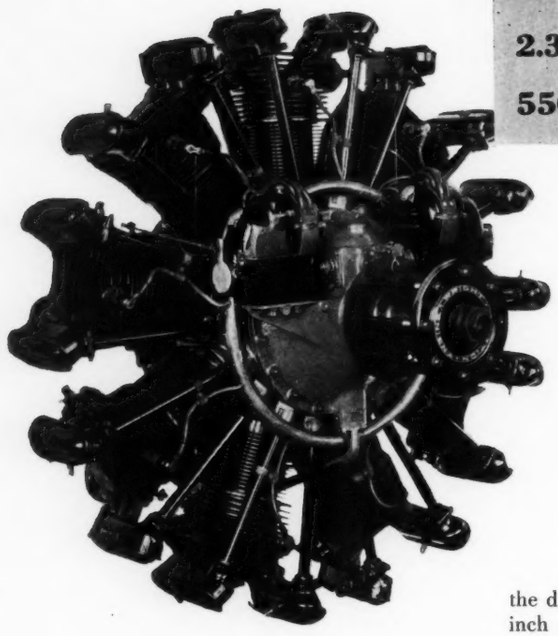
We suggest that the professors of the technical universities who are teaching machine design impress upon their students the necessity of establishing a factor of utilization on a logical basis rather than talking about the factor of safety and presenting ready-made empirical values for general application. It should be pointed out that modern design methods call for the elimination of arbitrary design factors, and demand that allowable design working stresses be established by an intelligent analysis of the known facts and the determination of the unknown quantities. And those designers who have not already accepted this change in the old conception of designing should study it carefully and bring themselves up to date.

1927

220 hp.

2.3 lb. per hp.

550 lb. per sq. in. explosion pressure



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CREDIT for the amazing developments in present-day airplane engines does not belong solely to their designers. New metals and alloys, improved machine tools, better foundry and machine shop technique and numerous other factors contributed greatly to this achievement. But it was the initiative of the airplane engine designers in seeking out, testing and adopting new materials, their cooperation with production engineers in taking advantage of improved production methods, and their keeping abreast of scientific research developments, which, added to their skill and ingenuity in design, created the airplane engine of today. The latest Wright engine, now in production, develops 1,500 hp. and weighs only a fraction over one pound per brake horsepower. Jules Verne is said to have made the statement that flying would not be entirely successful until 1 hp. could be delivered by an engine the size of a watch. Considering the size of watches in his day, this power-weight ratio has practically been reached.

But performance data, striking as they are, do not even indicate the innumerable problems that had to be solved. Conflicting requirements had to be reconciled; a new engineering design philosophy had to be brought into being and some cherished traditions had to be thrown away.

Here is a machine, the failure of which in a single-engine ship could likely be serious, possibly causing a forced landing, personal injury and damage to expensive equipment. Yet to attain the necessary light weight and compactness, the design must be such that every cubic inch of material will be stressed to the maximum safe value. The "factor of safety" must be low, the margin of safety must be high.

Frequently the "factor of safety" is referred to as the "factor of ignorance" because in most fields of engineering design it is used to avoid failure from unknown, uncontrollable or unpredictable factors. Some of these factors are low quality or defective raw materials, uncontrolled variables in heat-treatments, poor workmanship, incomplete analysis of loads, stresses and deflections, and design calculations that do not cover stress concentration fatigue failure. Evidently, if these "factors of ignorance" are minimized, eliminated or controlled, it is possible to use much higher design stresses and yet have the assurance of a greater margin of safety. This philosophy of "maximum utilization through complete design analysis and control of quality variables" has served as the basis of the design procedure that created the mechanical pygmies of giant power that are repeatedly smashing flight record after flight record.

To assure raw materials and finished parts of uniform high quality in all respects, and thereby make possible the use of a high "utilization factor" with

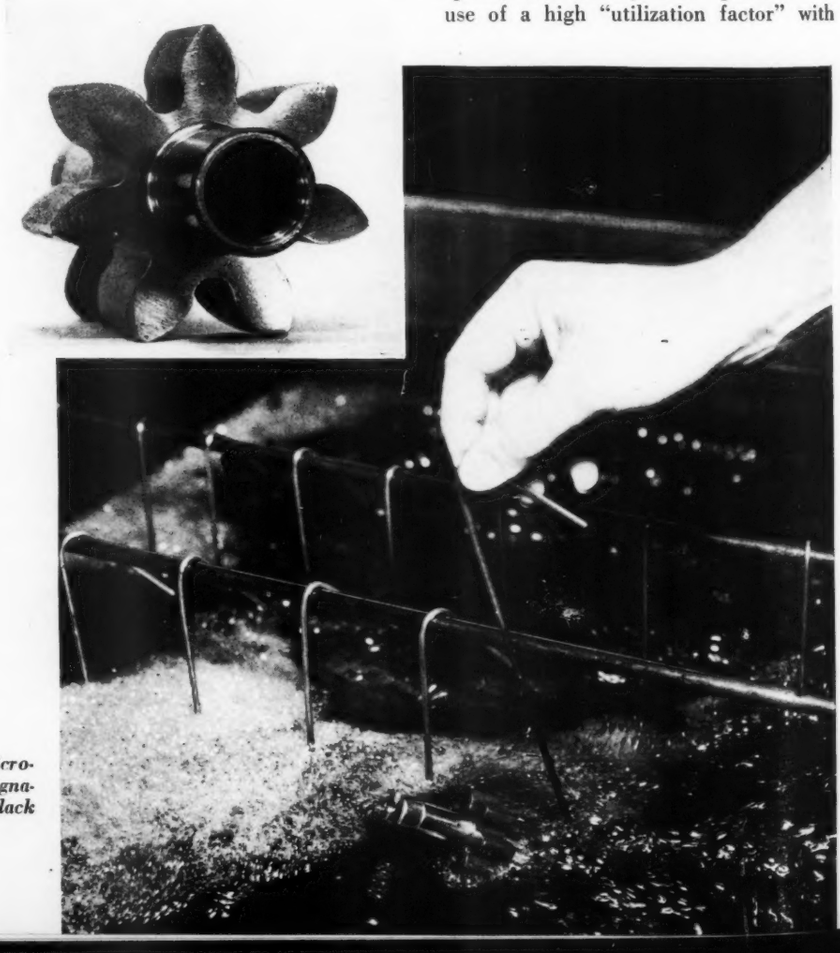


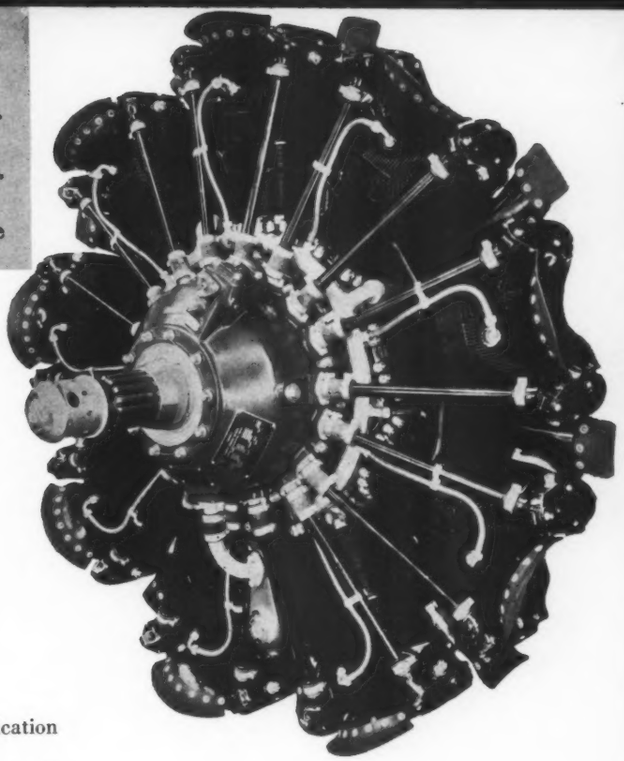
Fig. 1—Inspecting a pinion for microscopic cracks by immersion in Magnaflux bath. Insert shows the way black oxide clings to cracks

1937

1,100 hp.

1.08 lb. per hp.

850 lb. per sq. in. explosion pressure



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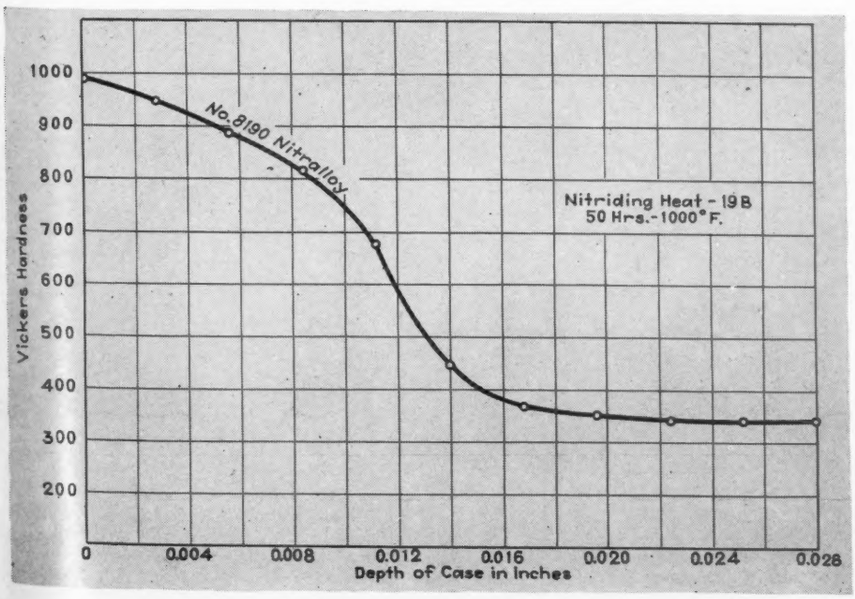
complete safety, an exceptionally well organized quality-control department checks all materials and all the parts at every step in their production. Chemical analyses, physical tests, hardness tests before and after heat-treatments, close scrutiny of surface finishes and inspections of form and dimensions make it unnecessary for the designer to apply a "factor of ignorance" to offset variables and defects in production.

As an added precaution steel parts are given the Magnaflux test to prevent from being used any piece in which the material is defective. The piece is magnetized and dipped into an oil bath that contains powdered black magnetic iron oxide, the bath is constantly agitated by compressed air. If the piece has even a microscopic crack, the iron particles will concentrate at the edges of the crack and cling there, giving a plain indication of its presence.

The total number of inspections on all of the parts that go into a Wright engine is of the order of 30,000. In addition to this, every engine is given a 5 hr. "green" test run to bring it up to 0.9 rated power at rated speed, then it is run for 1½ hr. at 0.9 rated power and rated speed, followed by ½ hr. at full rated power and speed, and then 15 min. at take-off power and speed, after which the engine is completely disassembled, every part carefully inspected and then reassembled. The engine is then given a final test run consisting of 2 hr. running-in to 0.9 rated power and speed, ½ hr. at 0.9 rated power and speed, ½ hr. at rated power and speed, then 15 min. idling, finishing with a 10 min. acceleration check. The engine is then cleaned and packed for shipment. Failures that can be attributed to materials or workmanship not up to specifications are of extremely rare occurrence.

Fig. 2—Hardness of case at various depths below surface of a typical nitrided part which had been subjected to a 50 hr. 1,000 deg. F. nitriding heat

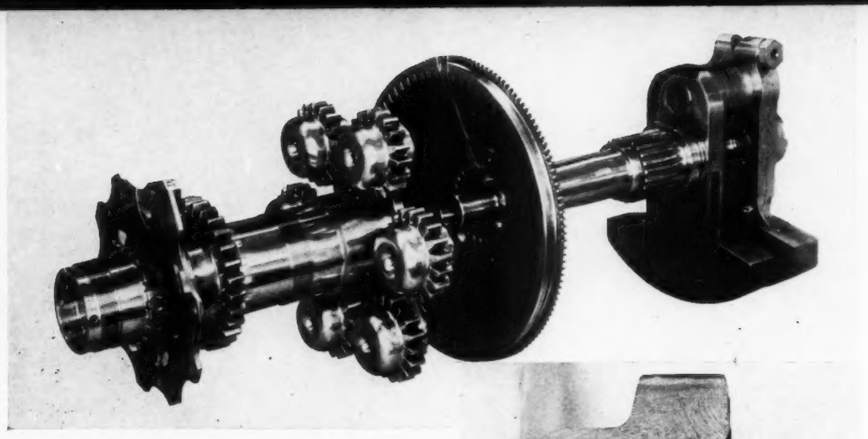


In ordinary mechanical design, unpredictable stress is another large contributor to the "factor of safety." Such stress usually includes concentrated stress, fatigue and stress that cannot be computed. In the design of airplane engines, areas of stress concentration are carefully avoided, and parts subjected to fatigue are designed with stresses below the endurance limit of the material. If the stresses cannot be calculated with the desired degree of accuracy, the parts are subjected to exacting endurance tests and the allowable load is thus determined.

Similarly, in addition to thorough mathematical analyses, tests and researches have established the maximum and normal loads to which various parts of the engine will be subjected. Thus, there is little possibility of any engine part being subjected to a load that it was not subjected to in testing.

With the assurance that the materials used will have the strength and properties specified and that the parts will be made according to the drawings, and with factual data leaving nothing to guess and tests to substantiate the correctness of the methods of calculations, the designers can safely use working stresses that would be considered foolhardy in most other fields. Thus, many parts are designed to be subjected to stresses surprisingly close to the endurance limit of the material.

Through the use of high working stresses a light compact engine is obtained. This largely accounts for the decrease in weight from 2.3 lb. per hp. in 1927 to 1.08 lb. per hp. in 1937. But



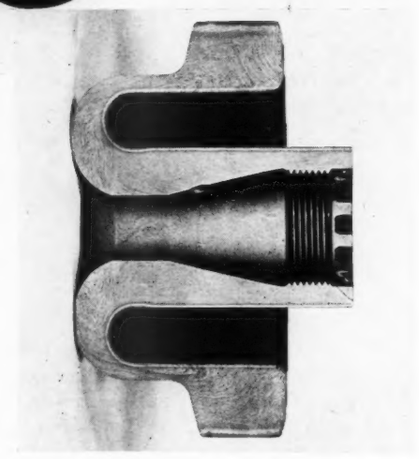


Fig. 3—Sun and planet gear reduction unit, an exploded view showing crankshaft and impeller shaft. Insert shows a cross-section of flexible recessed construction of planetary pinion

the increase in life of these engines has resulted largely from increased wear resistance because of better materials in the parts, in conjunction with the great advances made in the development of lubricants. And when it is considered that during this last decade the maximum explosion pressure on the piston head at rated power increased from 550 lb. per sq. in. to 850 lb. per sq. in., and temperatures increased correspondingly, it is apparent that the wear resistance of the important surfaces must have been greatly increased. The most severe wear conditions are imposed on the cylinder and piston walls, not only on account of the high pressures and temperatures, but also because of partial film lubrication.

Details About Nitriding

About two years ago the Wright engineers began using in production nitrided steel cylinder barrels. In the experiments and tests prior to adopting nitriding, a great deal was learned about the behavior of nitrided surfaces. As shown by the accompanying curve, Fig. 2, the hardness of the nitrided case or skin diminishes only slightly for the first few thousandths of inch below the surface, and then drops rapidly until at a depth of about 0.017 in. below the original surface the hardness is approximately that of the untreated metal. Another important point is that the surface as nitrided is of a microscopically pitted or granular character. This surface must be removed to a depth of 0.001 to 0.003 in. by either grinding or honing to secure best possible wearing surface. Unless this is done flaking or spalling will probably result if exposed to severe conditions. Therefore, all nitrided parts in Wright engines are finished to a mirror-like surface. The amount of metal removed after nitriding is only about 0.001 in. and therefore surface hardness is assured.

Parts to be nitrided are put in a furnace through which ammonia gas is flowing. Several hours are required to bring the furnace up to 1,000 deg. F., at which temperature it is held for about 50 hr., and then allowed to cool to room temperature before exposing parts to the atmosphere. The depth of case depends upon how long the furnace is held at 1,000 deg. F. and also the size and nature of the part. The surfaces that are not to be hardened are masked by tinplating.

Exhaust valves stems and certain gear teeth are also nitrided. In every instance, the nitrided case is ground smooth to prevent flaking. Only one of every pair of meshing gears is nitrided, the other gear being casehardened and ground. Experience shows that a pair of nitrided gears running together do not have satisfactory endurance properties.

Pistons are anodized which gives them an aluminum oxide surface, the hardness of which is comparable to that of carborundum. Thus both piston and cylinder walls are exceptionally hard and wear resistant.

Also for wear resistance, exhaust valve seats are Stellited and ground and a button of Stellite or of tungsten carbide is welded on the end face of the valve stems where they contact the valve rockers.

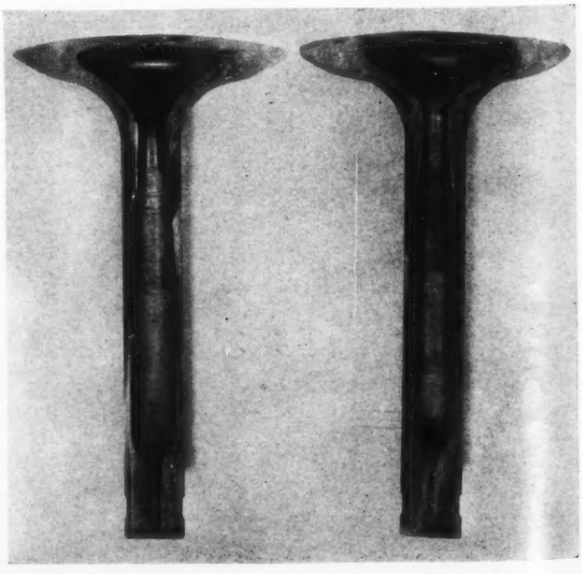


Fig. 4—Cross-sections of exhaust valves which are filled with metallic-sodium to improve removal of heat

Design of the gear reduction unit between the engine and propellor presented many difficulties. It had to be light and compact, yet capable of transmitting 1,000 hp. or more at an engine speed of 2,200 r.p.m. and drive the propellor at 1,512 r.p.m. Because it is inherently compact, a planetary type of reduction is used. The sun or central gear is held stationary, the pinion spider is fastened to the propellor shaft and the ring gear is driven by the crankshaft.

One problem was to keep the teeth of the pinion gears in exact alignment, an essential requirement because of the high speeds and loads involved. Pinion stud shafts stiff enough not to deflect would have been much bigger in diameter than required for strength and bearing area and would have necessitated a correspondingly larger and heavier gear unit. Larger pinion diameters would have been required to accommodate the larger bore; and the size of the other gears would have had to be increased correspondingly.

A glance at Fig. 3 shows how this problem was solved. The undercut pinion rim permits the teeth to deflect to compensate for any deflection of the gear mounting. Thus the gear teeth are virtually self aligning.

Engine horsepowers were increased by higher speed, higher mean effective pressures and somewhat larger cylinders. Each one of these factors meant that the amount of heat dissipated per unit of superficial area had to be increased. The problem was solved by using deep closely spaced integral fins on the aluminum cylinder head and on the steel cylinder barrel, proportioned and spaced to give the greatest cooling efficiency, as determined by experiments and tests.

Fins on the cylinder heads are 1½ in. deep, 3/32 in. thick, with 3/32 in. space between them. They give a total

cooling area of about 2,000 sq. in. The foundry technique that had to be developed to cast such heads can well be imagined. About 1,300 pieces of fine pointed wire must be carefully inserted by hand into the thin fin core walls in the mold to reinforce the sand.

The cylinder barrels have the fins 7/16 in. deep, 1/32 in. thick, and 3/32 in. space between them, cut in the forging. These fins give a cooling area of about 800 sq. in. Thus each cylinder has a total of about 2,800 sq. in. or 20 sq. ft. of cooling surface—greater than the area of a large flat-top desk. The finned construction also contributes greatly to the strength and stiffness of the cylinders. The wall of the steel barrel is only 1/10 in. thick.

In developing the design of the exhaust valve it was soon realized that the rate of heat conduction through metals was not fast enough to carry the heat from the valve head down through the slender stem and out through the air cooled valve stem bushing. The solution was a hollow valve partially filled with metallic sodium, a development of S. D. Heron of The Ethyl Gasoline Corporation of Detroit. At operating temperature the metallic sodium melts and the liquid is agitated by the valve movements. Thus the heat is transported rather than conducted by the liquid sodium which is heated at the valve head and travels down the stem to the cooling surfaces as a result of the churning it receives. Of course, conduction and convection also play a part.

In Fig. 4 is shown a cross-section of a hollow exhaust valve. It is interesting to note the varying wall thickness, heaviest under the head where the bending moments are maximum. Manufacture of the valve is also of interest. It is first machined as a cup with smooth inside walls to avoid stress concentration. The cup is then necked in by forging to form the stem, machined on the outside, filled with metallic sodium and the stem then plugged.

Valve guides and valve seats in the cylinder heads are held by shrink fits. Also, the cylinder head and barrel are held by a threaded and shrunk joint.

In assembling the cylinder head and barrel, the head is heated to about 600 deg. F., and the barrel at room temperature is screwed into it. So tight is this joint when head and sleeve are at approximately the same temperature that no leakage occurs at pressures far in excess of the explosion pressures.

Sleeve Bearings and Seals

The spark plug bushings are cooled in "dry ice" and screwed into the cylinder head at room temperature.

Both ball and roller bearings are used on the crankshaft. The connecting rod bearings are Cu-Pb, and carry loads as high as 5,000 lb. per sq. in. of projected area when the engine is dived. The integral centrifugal supercharger, which runs as high as 22,000 r.p.m., has sleeve bearings and plain thrust collars. Force feed lubrication accounts in part for the excellent bearing performance.

Fig. 5—Various piston-ring type oil seals used in Cyclone engine

Piston ring type seals of special design, with the outer member stationary, are used for sealing the supercharger passages from the engine crankcase. On test these seals functioned perfectly at 22,000 impeller r.p.m. and 20 in. of mercury pressure differential between supercharger and crank case.

High mean effective pressures and high piston speeds are conducive to greater torsional vibration, a serious problem. The older methods of torsional vibration damping added considerable weight and did not provide damping at all speeds. A device that would be effective at all speeds, regardless of the natural frequency of the crankshaft-propellor system, was needed.

Essentially, a torsional vibration damper is a device that exerts a torque that resists changes in angular velocity during the revolution of the crankshaft. The simple device that performs this function on Wright engines without increasing engine weight was originated by the Wright engineering staff and is one of the features that make possible the high power output of these engines. In principle, this consists of a mass or weight hung on two rollers supported in the crankcheek, the holes in the cheek and in the weight being appreciably larger than the roller diameter. Thus the weight is free to swing as a pendulum with a fixed period of oscillation.

In principle, as long as the crankshaft is rotating at a constant vibrationless speed, the pendulum weight exerts a centrifugal force radially outward, the line of action passing through the centerline of the crankshaft. An impulse tending to change speed causes the pendulum, because of its inertia, to "hold back," that is, swing back in its position relative to the crankcheek. The centrifugal force exerted by the pendulum then acts at an angle to the radial line passing through the center of gravity of the pendulum support. Thus this force counteracts the momentary change in angular velocity of the crankshaft.

A great deal more could be written about other amazing design features found in the Wright radial air cooled engines of today—the heat-treated aluminum alloy crankcase, the magnesium alloy cover plates, the elaborate lubrication system and the great care used to avoid points of stress concentration But, the real reason that the design of Wright aircraft engines is outstanding is that established facts and production quality control have made possible a design procedure wherein there is practically no "factor of ignorance."

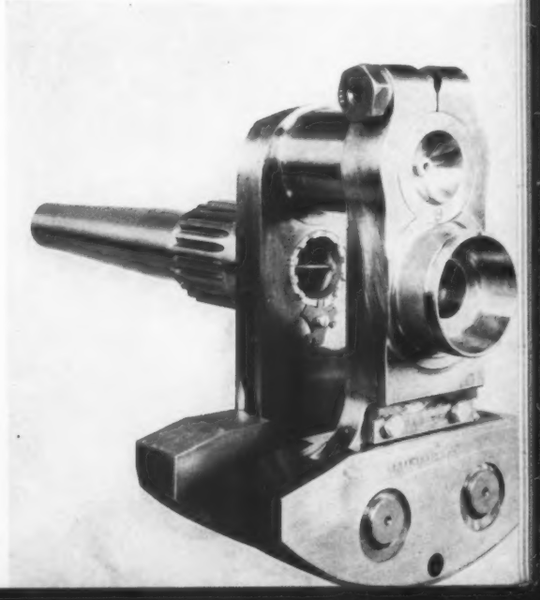


Fig. 6—Crankshaft of Cyclone engine with the dynamic damper attached

Product Developments

Interlocked Gear Drive for Adjustable-Speed Grinders

A four-speed gear drive, so interlocked with the wheel guards as to prevent overspeed, is incorporated in the adjustable-speed a.c. grinders manufactured by the United States Electrical Tool Company, Cincinnati, Ohio.

As shown by the accompanying illustrations, the inclosed driving motor is mounted on a pivoted, sliding support. When the foot pedal (Fig. 3) is depressed, the motor support pivots toward the rear of the grinder, disengaging the motor gear from whichever of the four spindle gears it has been driving. Sliding of the motor support to align its pinion with another of the spindle gears, which effects the speed change, is done by a rack and gear operating from a hand lever.

Bevel-geared to the rack-gear shaft is a transverse shaft which, by means of the linkage shown in Fig. 4, interlocks the speed change with the wheel guards. This interlock makes it impossible to run the wheels at a dangerous speed, because, when the guards are opened wide for a large-diameter wheel, only the slowest-speed gear can be engaged. However, as the wheels wear down and the guards can be brought closer to the flanges, the drive can be shifted to successively faster speeds.

To assure that the motor gear will mesh properly in each position, four screw-adjusted bumpers are provided. In addition an interlock switch, actuated by the pivotal motion of the motor support, makes it impossible to start the motor until the gears are in proper mesh.

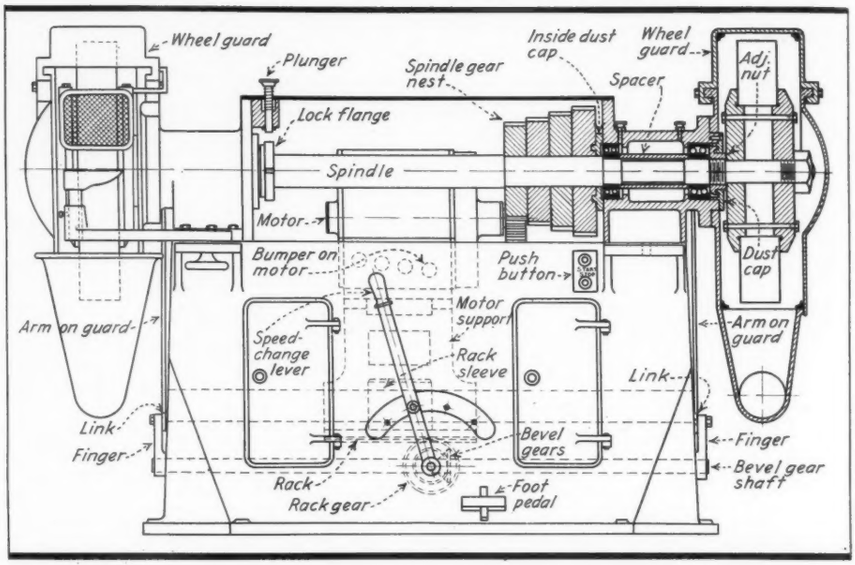


Fig. 2—Speed change is effected by pivoting motor support backward until gears are disengaged and then shifting it transversely to next faster gear ratio

Fig. 1—Nest of four spindle gears driven by motor gear provide successively faster speeds compensating for wheel wear

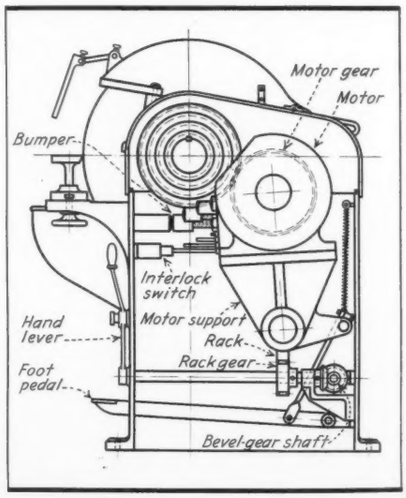
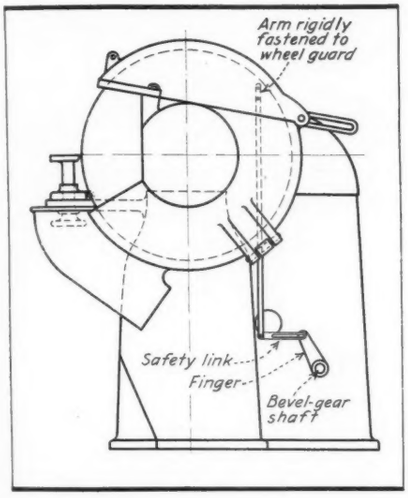


Fig. 3—Bumpers assure correct mesh of gears while interlock switch makes it impossible to start motor when gears are not fully engaged

Besides the interlocked drive, several other design features of the grinder illustrated are interesting. It has a one-piece chrome-manganese steel shaft supported by four heavy-duty ball bearings inclosed in a dustproof housing and protected on the inside and outside by labyrinth seals. Wheel guards are of boiler plate and are of the adjustable type with fixed exhaust connections arranged so that adjustment of the guards does not interfere with exhaust outlets. Wheel flanges are keyed to the spindle and are provided with adjustable weights, mounted in grooves on the sides of the flanges, for balancing the grinding wheel.

Fig. 4—This linkage interlocks wheels guards with transverse shaft bevel-geared to speed-change mechanism, thereby preventing dangerous speeds



Transparent Plastic for Fuse Head

Revolving head of Pierce Manufacturing Company's "Roto-Fuz" is now injection-molded of transparent Lucite by Erie Resistor Corporation's Plastics Division. Transparency is illustrated here by ampere rating which is clearly visible through front of molded piece. Part is light in weight, does not chip when rotated in its socket, and is said to give a more pleasant sensation when touched than material formerly used

Centrifugal Sand Muller

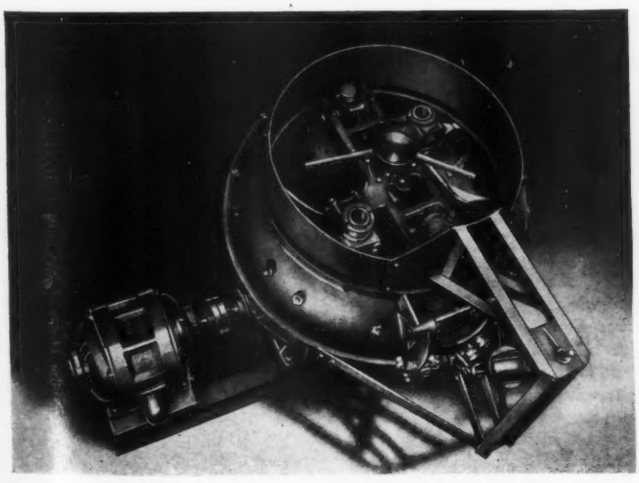
The centrifugal action of two rubber-covered steel balls is the basic principle utilized in a new type of foundry sand mulling machine recently introduced by the Beardsley & Piper Company, Chicago, Ill. Known as the "Speedmullor," the machine is designed to work equally well in the conditioning of facing, backing or compound and oil core sand, and is said to reduce mulling time.

The mulling mechanism consists of a crosshead mounted on a vertical shaft, revolving at approximately 90 r.p.m., from which the two 20-in. diameter spherical mullers are pivotally supported so that they may swing outward by centrifugal force. Their throw is adjustable by means of stop screws in the crosshead.

The crosshead is also equipped with two outside and two inside plows for delivering the sand outwardly, inwardly and upwardly and for holding the sand in suspension in the path of the mulling balls. In the effective muller track area, the sand is subjected to approximately two mulling and four aerating actions each revolution. The crosshead is equipped with a funnel and deflector pipes for convenient moisture additions.

A double-reduction gear unit, built integrally into the base, drives the crosshead shaft, the unit being designed for direct-connection to the 50-hp., 1,800-r.p.m. motor. The air-cylinder-operated discharge door in the side of the muller bowl operates through a toggle mechanism, can be remotely controlled, and is capable of discharging the sand in but a few seconds. Anti-friction bearings are used throughout, with adjustments readily accessible. Positive-pressure oil-pump lubrication is provided for the main bearings and the gears run in a bath of oil.

The combination of two rubber-covered spherical balls and two inside and two outside plows, all mounted on the revolving crosshead of this sand-conditioning machine, subjects the sand to two mulling and four aerating actions in each revolution



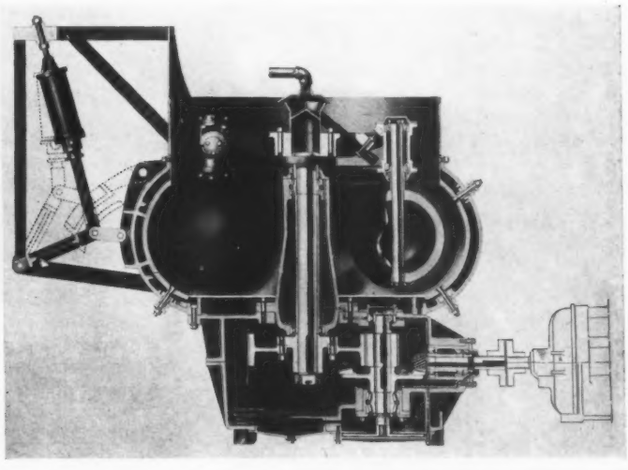


Fig. 1—Unprinted tape is carried over feed drum (top left), down over platen, and then back up to rewind reel (top center)

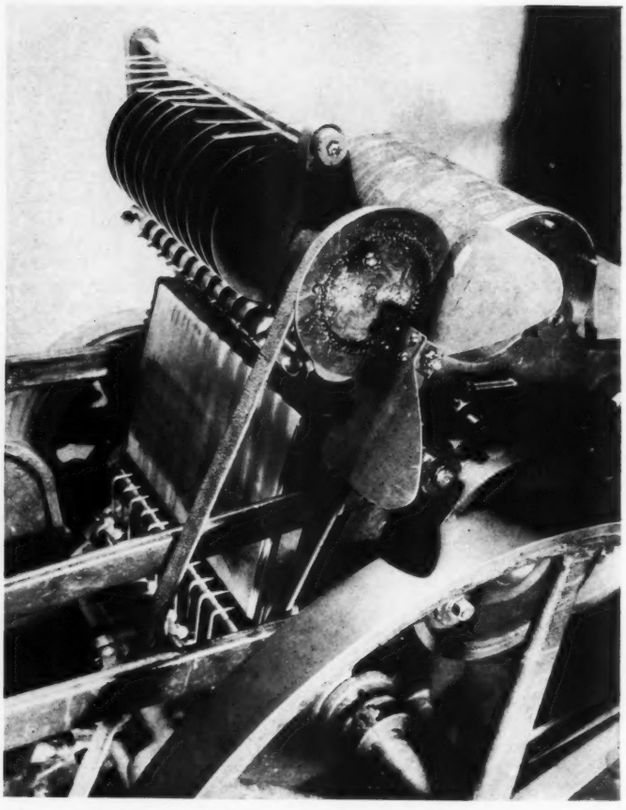


Fig. 2—Resistance of fan to turning determines torque transmitted by planetary pinions, on one of which fan is mounted, to rewind reel shaft

Fan-Controlled Tension

An unusual method of utilizing a fan to maintain the desired amount of tension during a rewinding operation is employed in a printing-press attachment recently developed for printing gummed package-sealing tape in the form of continuous rolls.

The attachment, designed by R. C. Hurst of Chico, California, is intended for application to platen presses. The platen, however, is kept stationary, and the device is therefore applicable to existing presses having worn-out platen mechanisms.

The unprinted tape, as shown in Fig. 1, is carried over a rubber-covered feed drum (top left) down over the platen, and then back up to the rewind reel (top center). Adjustable guides align the tape with the type as the tape passes over the platen.

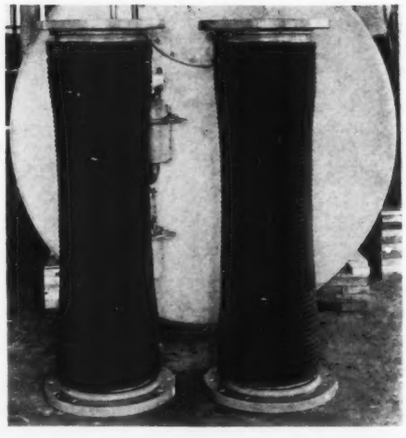
On the side of the feed drum is a series of pins, two of which can be seen in Fig. 2. These engage a trigger which locks the drum, thereby stopping the tape at the proper position and holding it stationary while the impression is made. It is this intermittent motion of the tape which makes it necessary to provide some means of (1) limiting the rewinding tension to a value that will not break the tape when it is suddenly stopped by the feed drum and (2) maintaining sufficient rewinding tension to keep the tape taut during the acceleration that occurs when it is shifted between impressions.

The double-bladed fan accomplishes the desired effect. It is mounted on a planetary pinion similar to the one which can be seen near the top of the internal ring gear in Fig. 2. The studs about which the pinions revolve are fastened to the flange on the end of the rewind-reel shaft. The ring gear, driven at constant speed by the belt, is free to revolve around the flange.

With this arrangement, it can be seen that the resistance of the fan to turning determines the torque transmitted by the pinions to the rewind-reel shaft. When the feed drum stops the tape, and the tape in turn stops the rewind reel, the fan simply speeds up, the effect of its inertia and increased air resistance being insufficient to break the tape. On the other hand, when the tape accelerates, the fan slows down but the effect of its air resistance is still sufficient to keep the tape taut.

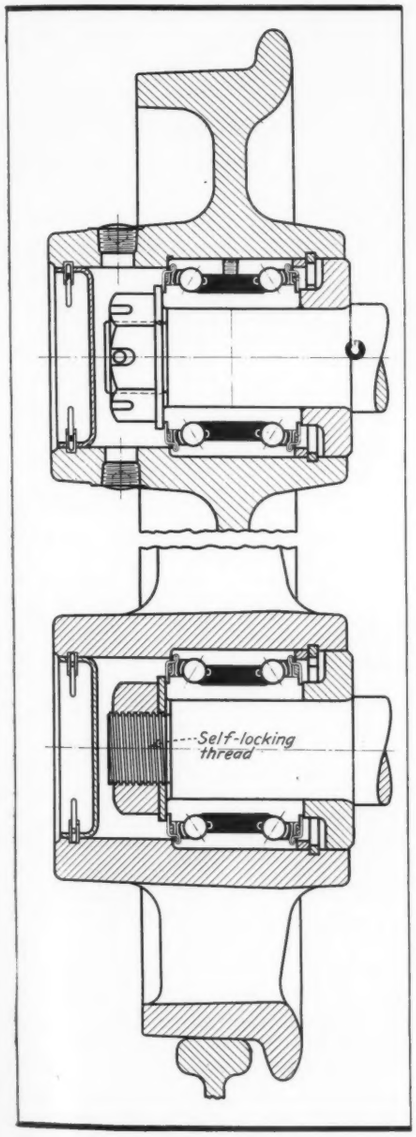
Large Scale-Hose of Synthetic Rubber

Confronted with the problem of obtaining 12-in. hose that would be unusually flexible and resistant to gasoline and oil, the Richardson Scale Company adopted Thiokol synthetic rubber as the material. The hose, two lengths of which are shown here, was produced by the Manhattan Rubber Manufacturing Division of Manhattan-Raybestos Inc., and is used to convey gasoline and oil to a giant liquid-weighing scale

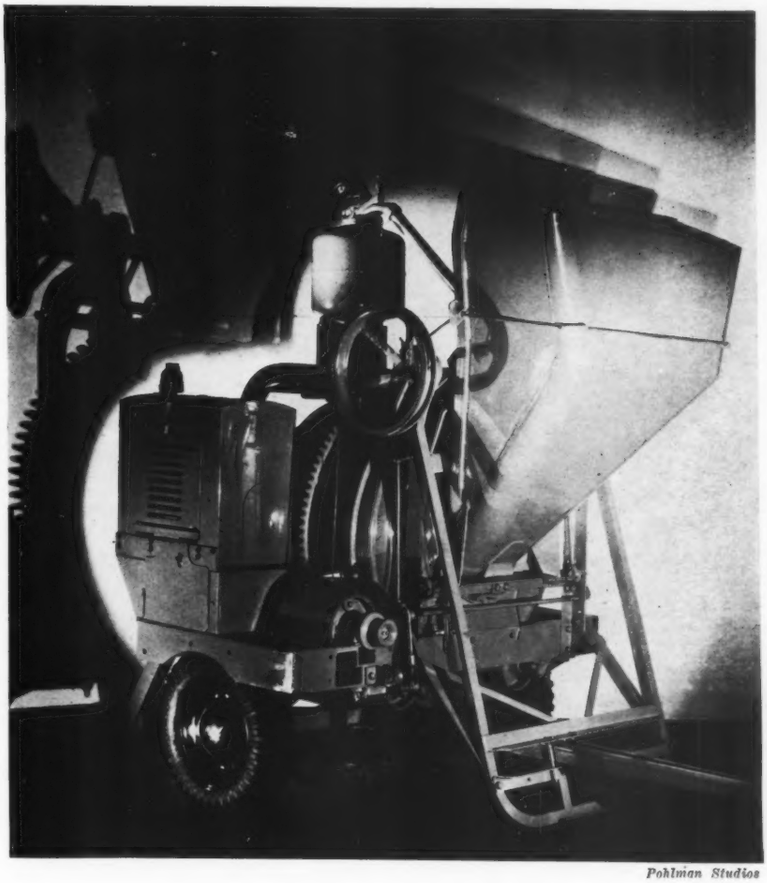


Self-Locking Simplicity

How the use of a locknut with a self-locking thread can simplify construction is shown in the accompanying illustration comparing two New Departure designs of mine-car wheel bearings. The wheels are similar except that the one on the right eliminates the necessity of providing plug holes and cotter pins. A Dardelet self-locking screw thread is used for the locknut. With this thread the nut locks at any point where it reaches sufficient locking friction and, once locked, it is claimed to successfully resist severe shock and vibration. Besides simplified construction, the self-locking design considerably reduces the time required for assembly and disassembly.



Mine-car wheels identical except that plug holes and cotter pins used in one are eliminated in other through use of locknut with self-locking thread



Pohlman Studios

Stripped for Action

With excess weight pared materially through the use of high-strength alloy steels, the latest model Koehring concrete mixer shown in the accompanying illustration is from 25 to 40 per cent lighter than previous models. In addition, the use of pneumatic tires and anti-friction bearings, combined with two-wheel mounting and attention given to correct balance in the design, make possible high trailing speeds for this type of machine during transportation from job to job. Other features include multiple V-belt drive, full-floating spring mounting, automatic syphon-type water-measuring tank, and an automatic skip-flow shaker

Sine Bars for Gear Checking

How a sine bar can be used either for setting a machine or for obtaining a ratio of movement between two moving parts, or for controlling the movement without the use of a lead screw, is exemplified in two gear-checking machines recently developed by the Michigan Tool Company, Detroit, Mich. One is a combined tooth form and tooth spacing checker, the other a spiral lead checker.

The sine bar on the combined involute and tooth spacing checker acts as a compensator for the differences between the lengths of arc on the friction disk that originates the machine movement on the base circle of the gear being checked. Fig. 1 shows the machine and Fig. 2 illustrates the method of obtaining the combined readings (see next page).

The friction disk is integral with the work holding spindle and imparts movement to the sine-bar carriage. The angular setting of the sine bar controls the movement of the indicator head, which is counterweighted to hold it against the sine bar. Each degree of work rotation can be read on a scale beside the sine-bar carriage.

On the spiral lead checker, shown in Fig. 3, the spiral lead is checked in preference to the helix angle for the reason that the lead is constant no matter at what depth or portion of the tooth the measurement is taken, whereas the specified helix angle is correct only at one diameter and varies with the depth at which the measurement is taken.

The sine bar on this machine is set

Fig. 1 — Combined tooth form and tooth spacing checking machine

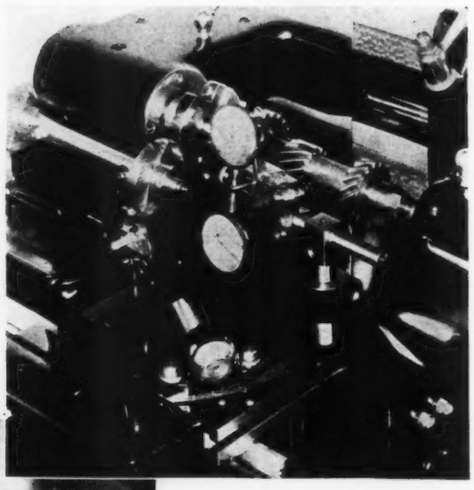


Fig. 3—Machine for checking spiral lead

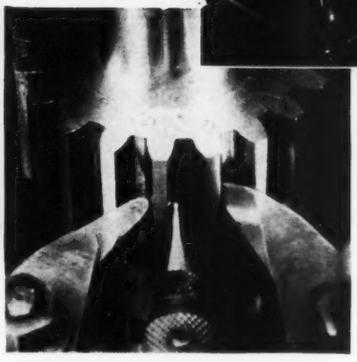


Fig. 2—Method of obtaining combined reading of tooth form and tooth spacing

to correspond to the correct spiral lead by means of two measuring buttons. The sine-bar carriage and the indicator are moved by a handwheel parallel to the axis of the gear. A clevis straddling the sine bar moves the upper carriage at right angles to the sine-bar carriage. The work-holding spindle is revolved by the friction of two lapped blocks on rolls. In this way indicator movement and gear rotation are synchronized during checking. When the indicator is in contact with the gear tooth, any variation from the proper lead is shown.

Die-Cast Stapling Machine

Three simple zinc-alloy die castings, shown in foreground, constitute the essential parts of the "frame" for the Heller Company's stapling machine for general tacking work, shown in background

RANDOM JOTTINGS ABOUT NEW DEVELOPMENTS

A number of manufacturers, such as Vail Steel Products Company, are using stainless steel for heat-resisting applications in furnace construction.

* *

Average loss in thickness of the stainless steel flame rims and diffuser grilles of Timken oil burners amounted to only 0.00054 in. after two years of severe service. With a 10 per cent safety factor, this loss indicates a theoretical life expectancy of 56 years for the average flame rim.

* *

A lacquered rubber covering on the lens frame and base of the Hipwell Manufacturing Company's new flashlight provides a cushioning effect serving to protect the lens and bulb when the light is dropped. In addition the rubber prevents corrosion of the parts and acts as an insulator when the light is placed on a metal surface.

* *

A small thermometer dial, incorporated in Samson-United Corporation's new "Visumatic" electric hand iron, gives visual indication of ironing temperature. Purpose is to prevent the operator from using the iron too soon after the heat regulator has been turned from a higher to a lower temperature, thereby protecting fabrics from heat rot.

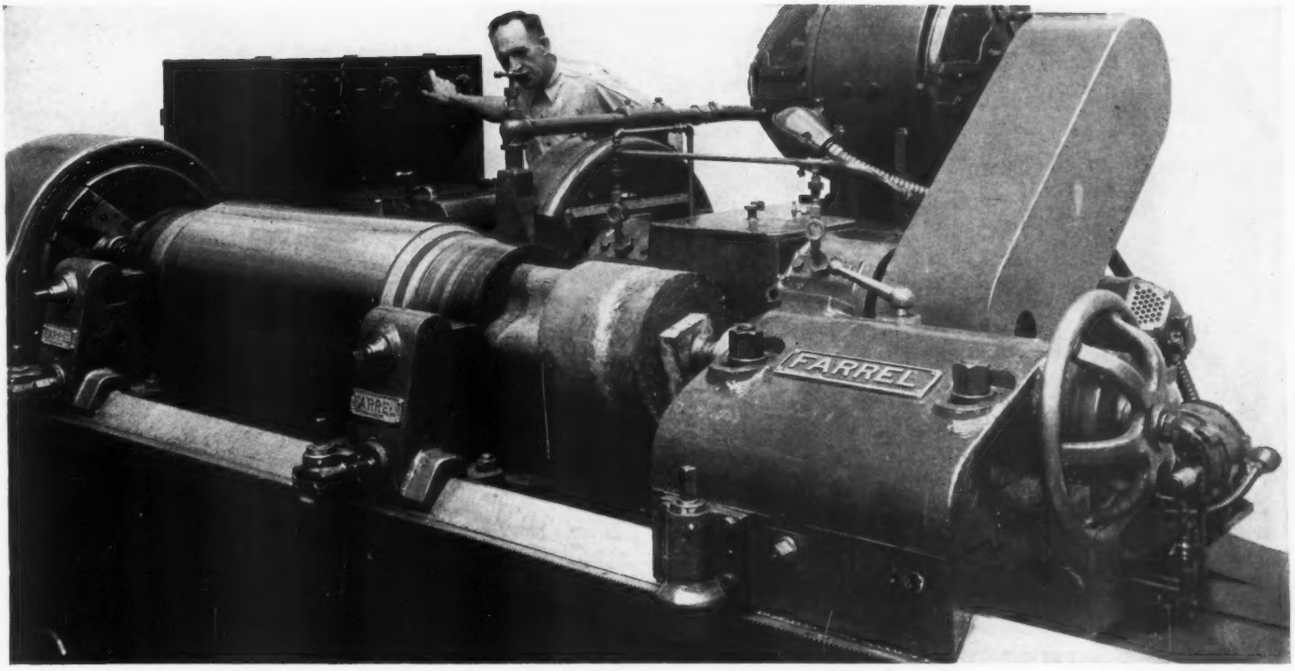


Fig. 1—Conveniently located controls, sturdy construction, essentially vibrationless operation, high productivity distinguish the modern roll grinder

MINIMIZING VIBRATIONS

In Heavy-Duty Machinery

HERBERT CHASE

How multi-motoring and the use of resilient drives eliminate or damp out detrimental vibrations in large roll-grinding machines, and how other features of design help to improve the accuracy and increase the productivity of these grinders

IN ORDER to turn out high-quality rolled products, steel mills, paper mills, and other large users of rolls that require resurfacing demand roll grinders capable of doing extremely accurate work and producing a superlative surface finish on the rolls in the shortest possible time.

In the current models of roll-grinding machines, these requirements have been met by refining various details of design to eliminate vibration and increase productivity. The basic problems involved and the manner of their solution are here presented as outlined to the writer by engineers of the Farrel-Birmingham Co., Inc., Ansonia, Conn., one of the leading manufacturers of standard and special machines for roll grinding.

Other conditions being equal, the smoothness of the surface produced will be determined by the degree of vibration of the roll being ground and the vibration of the grinding wheel. Vibrations originating in any part of the machine might be transmitted through the bed to the headstock, tailstock or steady-rests (See Figs. 1 and 2) and thus to the roll being ground. Torsional vibrations originating in the drives and transmissions might be transmitted to the roll and thereby produce chatter marks. Similarly, vibrations originating in the bed or wheel carriage and transmitted to the wheel spindle (Fig. 3) would likewise be detrimental.

Several lines of attack for the elimination of vibrations were followed. One was to simplify the machine drives so that there would be a minimum number of driving elements involved. Naturally this would result in minimizing the number of places at which vibrations might possibly originate.

Evidently, by using individual motor drives for each of the units of the machine, a great deal of shafting, gearing and other power transmission units would be eliminated.

Thus, the modern precision roll grinders are multi-motored. The grinding wheel is driven by its own motor and there is one for the grinding wheel feed. The carriage on which the grinding wheel is mounted has its own motor for traversing and there is a separate motor for the headstock drive. Also the coolant pump and the two lubricating oil pumps have their individual motors. All seven of the motors are direct current and, with the exception of the coolant pump and oil pump motors, have variable-speed control.

In the earlier machines positive chain and gear drives were used. But even

precision gears with ground teeth and no backlash did not prevent chatter. Some of the vibrations evidently originated in the motor armature. As the gears were improved so that they would not create vibrations they seemed to become better transmitters of vibrations. Hence chatter could not be prevented regardless of the accuracy of the gearing employed.

Headstock Drive

To do away with the gear drive in the headstock was not an easy matter, especially if a fully inclosed and compact drive was to be used, as desired. It was decided that a V-belt drive should be tried. First, partial data were obtained from an experimental setup on an older machine. Then a V-belt drive was designed and built for a 60-in. machine and a special experimental roll, weighing some 75,000 lb., was made for the purpose of testing the ability of the V-belts to rotate the roll.

From this work it was concluded, and later verified in practice, that a triple-reduction drive, using as many as 20 V-belts of standard size on one sheave, would yield the desired results not alone in respect to torque and speed requirements, but also within a relatively compact space and, of greatest importance, without vibration.

The design worked out employs overhung pulleys on which belt replacement is not difficult and adjustment of center distances, to take up on belts when required, is very easily accomplished. Fig. 4 shows a headstock with slotted pillow block having a screw adjustment for belt takeup, flexible oil piping, and a total of 47 belts in use. The unit is completely inclosed but readily accessible in service.

As an additional precaution against any tendency toward unequal rotation of the roll, a self-equalizing faceplate with a swiveling driving bar and adjustable driving dogs (Fig. 5) is employed. Accuracy is further promoted by the use of dead centers in both the headstock and the tailstock. Finally, to steady the roll during rotation, neck rests are provided and these have gibs with a convenient screw adjustment to facilitate quick and accurate set-up.

Of even greater importance in respect to precision and freedom from vibration, however, is the design of the wheel spindle drive, the spindle itself, and its mounting. A flat-belt drive with an idler had been used to drive the spindle but it had given rise to chatter resulting in part, at least, from a tendency of the idler to bounce at certain synchronous speeds. Direct motor drive could not be used because, in the size required, perfect dynamic balance is economically impractical.

For that reason, modern grinders utilize the cushioning effect of a V-belt spindle drive, usually at about a 1:1 ratio, from a variable-speed (575 to 1,150 or 1,450 r.p.m.) 30 or 40 hp. motor. Both the spindle and the motor are dynamically balanced to a point at which any remaining unbalance is too small to produce detrimental vibration.

The driven sheave is overhung at one end of the spindle and the grinding wheel at the opposite end, an arrangement which makes for ready wheel change and easy belt replacement. As no idlers are required, vibration from that source is avoided. Twelve belts are used in this drive for the larger machines and nine for the smaller.

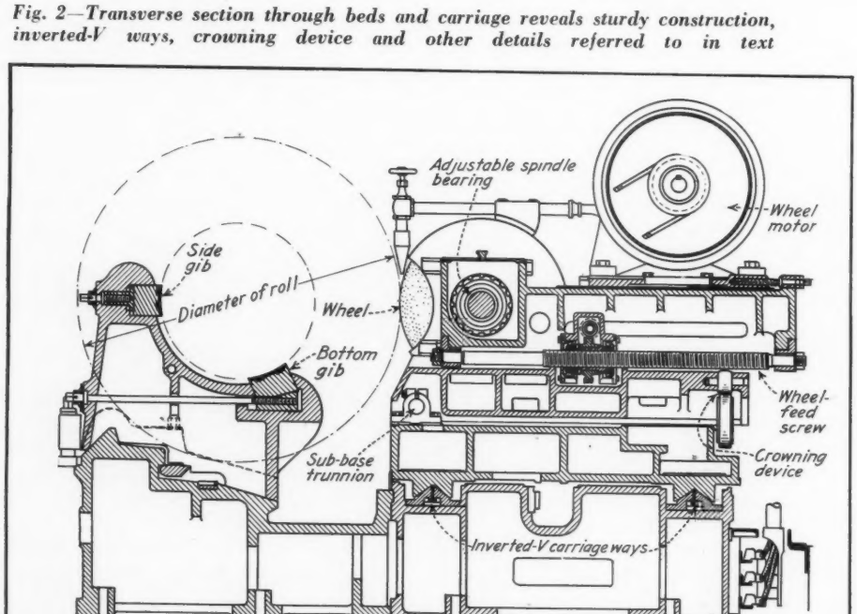


Fig. 2—Transverse section through beds and carriage reveals sturdy construction, inverted-V ways, crowning device and other details referred to in text

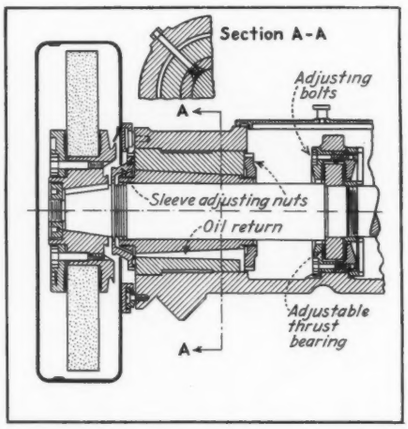


Fig. 3—Adjustable sleeve and thrust bearing constructions are shown by this longitudinal section of spindle

Construction of the wheel spindle and spindle bearings is shown in Fig. 3. The bearings are plain and are made with a high degree of precision. A choice of solid bronze sleeves or of steel with centrifugally-cast babbitt lining is offered. In either instance, the exterior of the shell is tapered and the sleeve has a longitudinal slot containing a key with tapered walls. Nuts at each end of the sleeve permit it to be adjusted and locked.

The adjustment is such as to vary the radial clearance within the very close limits required for a spindle which must run with extreme accuracy. The key, which expands the bearing shell against its seat, is held by bolts threaded into it. The reason means is provided for varying bearing clearance is to allow for the use of oil of different viscosity and also to permit of change with varying speeds of spindle drive.

Interlocked Lubrication

At the center of the spindle is a hardened and ground collar arranged between a pair of babbit-faced thrust bearings. These position the spindle endwise and take thrust loads. Either flood (with sight feed) or piped pressure feed of oil is employed. With the flood-lubricated system, a time-delay relay serves as an interlock, preventing the spindle motor from being started until the lubricating pump has been running a predetermined length of time. With the pressure system of lubrication, a pressure switch makes it impossible to run the spindle motor unless the oil is at proper pressure.

Longitudinal motion of the wheel carriage is effected by a planer-type drive with a reversing motor mounted on the carriage. Between the motor and the double reduction worm unit which drives

a rack on the main bed, thereby traversing the carriage, there are two sets of Sykes herringbone gears cut with high precision. A positive clutch is arranged so that either set can be put into use depending upon the speed of traverse required.

This form of drive is not only extremely smooth in operation, an essential to freedom from vibration, but also is relatively simple and compact. In addition, since the motor reverses and no reversing clutches are needed, shocks are avoided and further compactness is achieved.

The roll-cambering mechanism is located on the rear of the carriage, almost directly over the rear way of the bed. Since the deviation from a true cylinder may be only a few thousandths of an inch in a roll several feet in length, a high degree of precision is required.

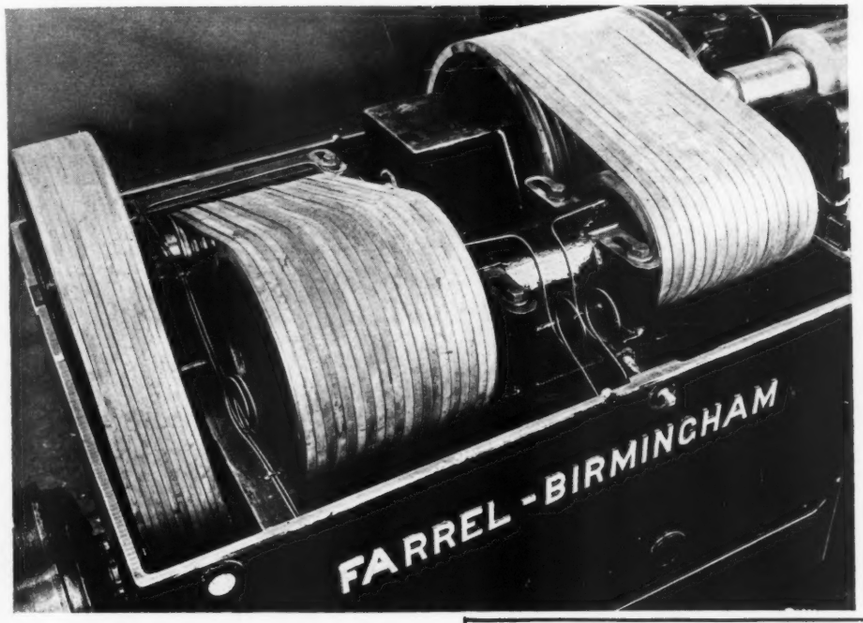


Fig. 4—Headstock drive effects triple reduction between motor and faceplate through groups of V-belts, 47 in all

Cambering Mechanism

As can be seen in Fig. 2, the carriage base is made up of two castings. Of these, the upper one is pivoted to the lower, the pivots being made without clearance on tapered horizontal trunnions well below the spindle axis and nearer to the roll axis than the spindle. With this arrangement, the upper part of the carriage can be rocked about the pivot, thus moving the wheel into or out of the work.

The third point of support is between two rollers (Fig. 6), the one in the upper casting having a fixed axis. The lower roller is so made that the axis about which it turns can be adjusted eccentrically. If set at one side of center, this cambering device makes the roll convex, and if set at the other, the roll is ground concave.

To control the concavity or convexity so as to yield the desired curve in relation to the length of the roll surface, the circular-cam roller must be turned in a proper relation to the traverse of the carriage along the bed. This is accomplished by the motion of a pinion geared to the roller and engaged with a rack on the bed along which the carriage moves. Gears which drive the roller include a pair which can be changed to correspond with rolls of different length, as desired.

Fig. 6—Close-up of circular cam, eccentrically adjustable for controlling camber of the roll

Parts involved in driving the roller are made with a high degree of precision and are assembled to minimize backlash. Any remaining backlash is taken up by an adjustment provided in the gearing. Adjustable gibs near the rear edge of the upper and lower casting of the carriage prevent longitudinal motion between these castings. The ease with which the cambering device can be adjusted makes for rapid setup of the machine for rolls to be ground with different curves as well as for grinding rolls of different length, contributing importantly to the high productivity of the machine.

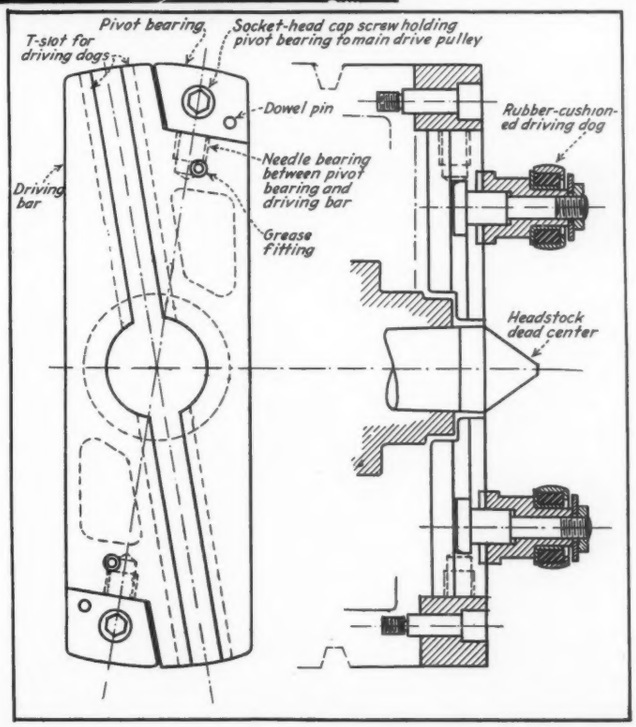
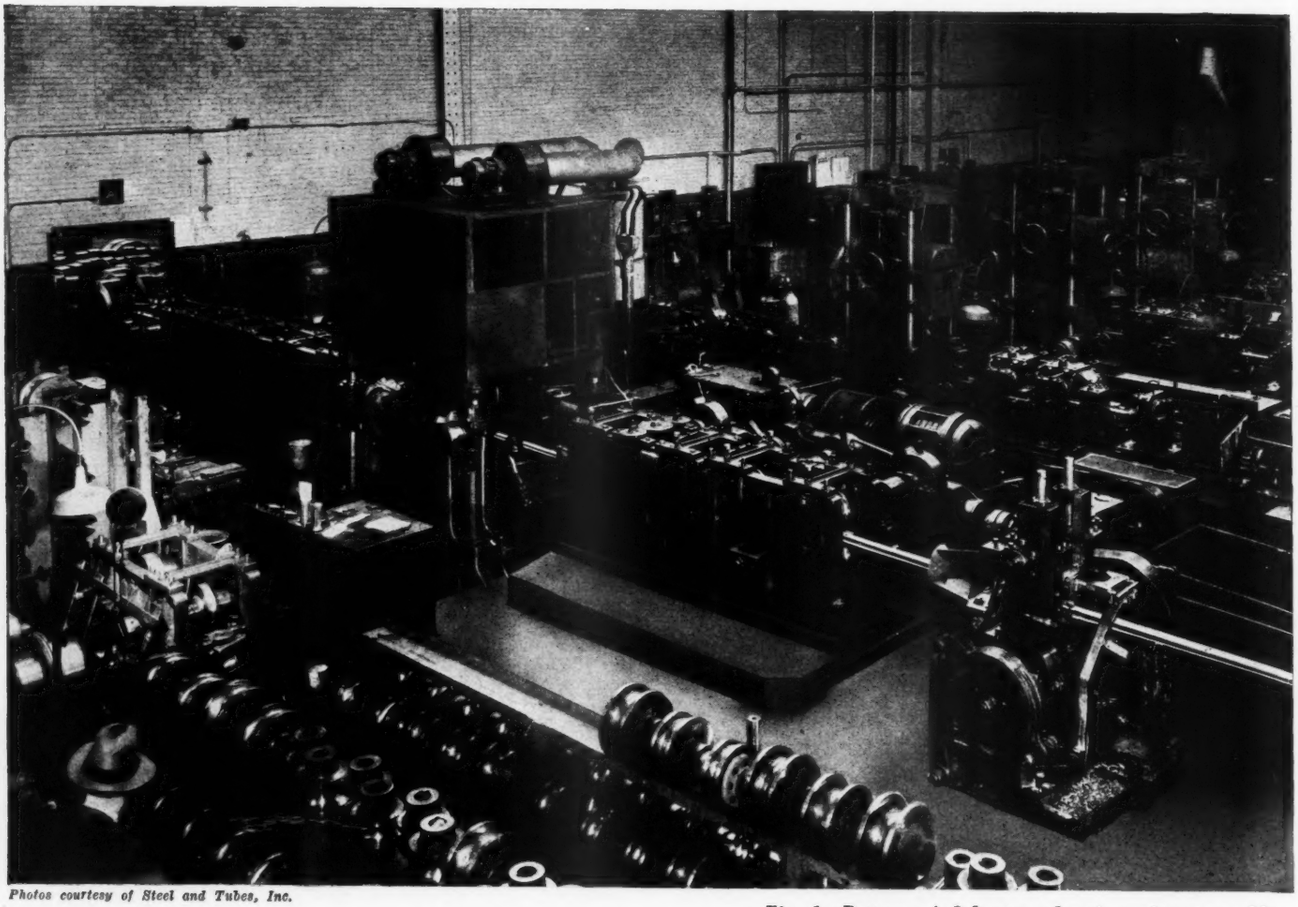

Pivot bearing
Socket-head cap screw holding pivot bearing to main drive pulley
T-slot for driving dogs
Dowel pin
Rubber-cushioned driving dog
Needle bearing between pivot bearing and driving bar
Driving bar
Grease fitting
Headstock dead center

Fig. 5—Details of swiveling driving bar and rubber-cushioned driving dogs used in self-equalizing faceplate



Photos courtesy of Steel and Tubes, Inc.

Fig. 1—Battery of Johnston electric resistance welders

STEEL TUBE APPLICATIONS

Advanced by Improved Welding Methods

Use of tubing is no longer limited by high costs of materials and shop assembly; new processes of manufacture and fabrication now produce a material that satisfies demands

ALTHOUGH long recognized by engineers as the strongest simple structural member for its weight, advances in the use of tubing as a feature of design were relatively few. Quite recently because of the removal of some major factors which limited its scope of structural applications, tubing is now spreading into new fields of use.

Formerly there was the objection of high initial cost. Today electric-resistance welded tubing can be manufactured for less cost than seamless tubing.

Regarding the structural strength of electric-resistance welded tubing, the U. S. Bureau of Standards states in the concluding paragraph of Research Paper No. 161: "This investigation shows that, except in the case of swaged annealed tubing, the properties of the base metal (metal not affected by the welding operation) can be used in determining the working stresses for different structural uses of tubing made by the process used in the manufacture of this electrically welded tubing, no allowance being necessary for the altered structure in and adjacent to the weld."

A second factor acting against the spread of the use of tubing has been the extreme cost of assembly and fabrication. This condition has been improved by the development of self tapping screws and spotwelding, and also by a process now becoming commercially available which will go a long way towards revolutionizing the design of tubular assemblies. By this process the component parts of a tubular frame can be assembled by electric resistance welding without any welding flash and without any polishing necessary prior to chrome plating, and the cost of this method of assembly is but a fraction of the present cost of assembly by arc welding, oxyacetylene welding, brazing, or bolting.

Still a third reason for designers not using tubing is the lack of available engineering data, such as physical properties and characteristics of various sizes and shapes of tubing. This scarcity of design information is gradually being overcome by the manufacturers.

With the removal of these three ob-

stacles, the scope of usefulness of structural tubular shapes which made possible the commercial success of the bicycle, the increased efficiency of the automobile (the torque tube drive and the hollow steering shaft), and progress in the design of the airplane, will be increased far beyond anything that may readily be imagined at the present time.

In the manufacture of electric resistance-welded tubing during the past few years, the size range and the analysis range have both been increased to an extent where practically every demand for a commercial product can be met. The raw material is a rolled product, hot or cold flat rolled steel, which prior to its being formed into tubular shape is inspected to insure the absence of those surface defects which are common to steel making practice.

Gage tolerances are close on steel used in the manufacture of welded tubing. There is very little variation in thickness across the width of the strip and as a result the finished tube is concentric. This is a property which is invaluable in many tube applications. The close tolerances adhered to also control the weight per foot of tubing, thus simplifying the design of structures based upon weight.

The strength of the weld is as great or greater than that of the base metal. The use of welded tubing is therefore adaptable to all applications where tubing is used, or where tubing can be used, to supplant and improve upon other methods of construction.

The continuous process is used in electric resistance tube welding. After the butted tube is formed, it is carried under a pair of roller electrodes, each of which makes contact with the tube on one side of the seam. A pair of supporting or pressure rolls are situated under the electrodes to support the tube and apply the pressure necessary for welding. Heat is generated by the resistance of the joint to the flow of a current of high amperage and low voltage, thereby raising the edges to welding temperature. Pressure is applied by rolls to force the edges together. No extra metal is added during the welding operation, the weld being a complete union of the butted edges. The microstructure at the weld is that of a heat treated steel, with no cast or overheated structure. Annealing after welding is necessary only when the stresses set up by the fabricating operation are such as to exceed the ductility of the base metal.

Electric resistance-welded tubing can be obtained in rounds, squares, rectangles, other regular shapes, and many irregular shapes.

The range of sizes of round electric resistance-welded tubing now available runs from 3/16 in. min. to 5 in. max. outside diameter. Shapes other than rounds are limited to a periphery of from 9/16 in. to 16 in. The range of wall thicknesses is from 22 to 3 Birmingham Wire Gage, that is, from 0.028 to 0.259 in. By the same process pipe is now welded up to 16 in. dia. and 0.554 in. wall.

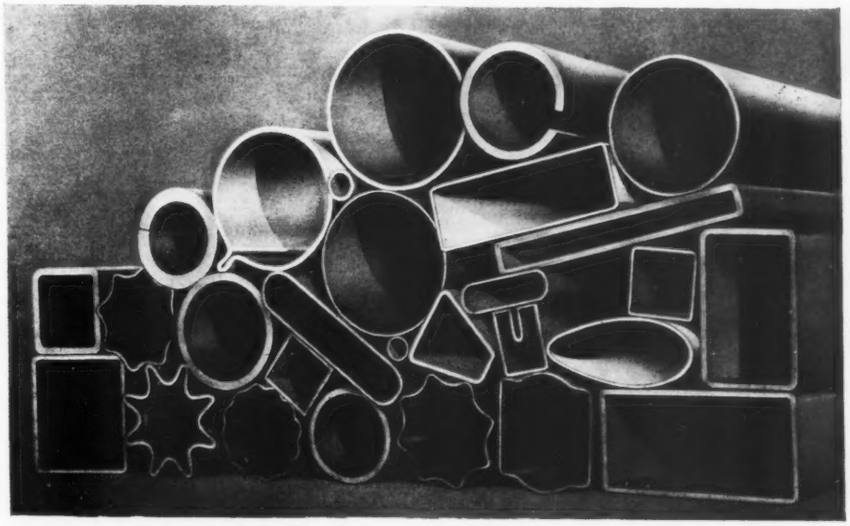


Fig. 2—A few of the various shapes of sections in which electric resistance welded tubes are available

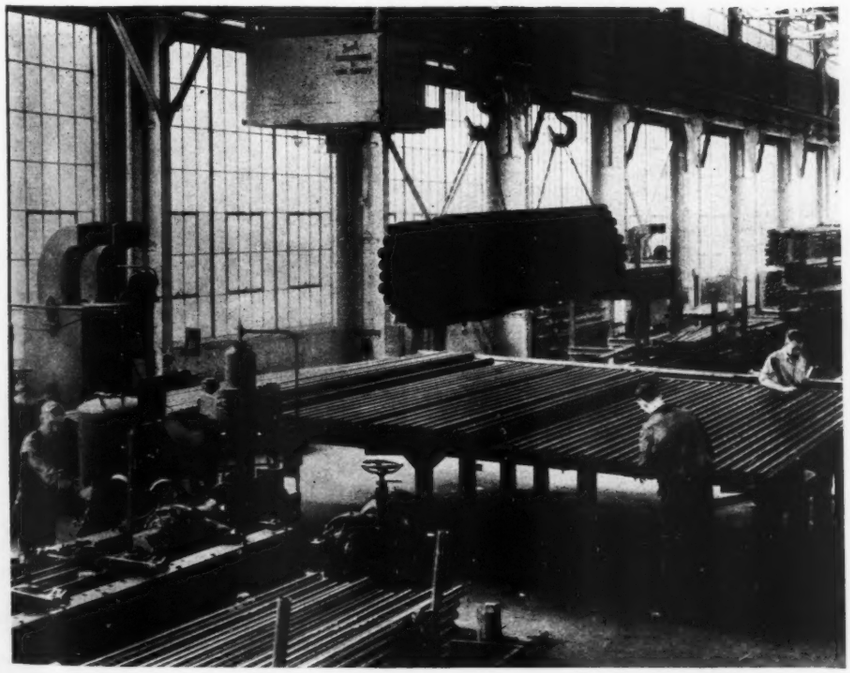


Fig. 3—Testing and inspecting tubes is as essential an operation as is the inspection of the material from which they are made

In standard practice, outside diameter tolerances range from plus or minus 0.003 in. on small tubes to plus or minus 0.020 in. on large tubes. Corresponding limits apply on shapes other than rounds, although in non-circular shapes other factors enter. For example, in a square or rectangular tube the longest side of which does not exceed 2½ in., there is a tolerance on the side to side measurement of plus or minus 0.010 in. to take care of the convexity or concavity of the surfaces. The tolerances used in standard practice can be bettered as much as 25 percent for special applications with a moderate increase in cost. It might be well to caution against insisting on extremely "square" corners in a tube of any shape, since a sharp corner can be obtained only by working the metal far beyond its elastic limit, in which condition an opportunity

TABLE I. Physical Properties of Electric Resistance Welded Tubing

	Yield Point Lbs. per Sq. In.	*Ultimate Lbs. per Sq. In.*	*Per Cent Elongation in 2 In.*	*Hardness Rockwell B Scale*
SAE 1010 Medium	45,000	55,000	25	60
SAE 1010 Hard drawn	55,000	60,000	10	75
SAE 1020 Medium	55,000	65,000	20	65
SAE 1020 Hard drawn	65,000	70,000	10	80
1.00 to 1.40 Manganese	60,000	75,000	15	95
High tensile—low alloy	70,000	85,000	15	95
Chrome Nickel 18–8S	45,000	90,000	35	90
Rail Carbon Steel	65,000	95,000	10	95

exists for rupture when under continued stress, and unfortunately this condition cannot be entirely remedied even by subsequent heat treatment.

The process of manufacture of electric resistance-welded tubing is adaptable to a wide range of analyses. By far the most widely used for structural purposes, however, is SAE 1010 steel. Some of the reasons for this are: flat rolled steel is readily available in this analysis, it has sufficiently high physical properties for most applications and it is easily fabricated and welded which is important in connection with its uses in the automotive field.

In the manufacture of tubular furniture it was found advisable in some instances to go to a slightly higher carbon steel and SAE 1020 was used. In the processing of this material the tube was welded slightly oversize and finished to size with a cold-drawing operation to raise the elastic limit.

For torque-tubes and propeller shafts in automobiles, where a high elastic limit is desired, SAE 1010, 1020 and 1025 are cold worked to obtain the desired physical properties. These tubes are subjected to the severe torsional strains of sudden acceleration and deceleration accompanying the operation of a motor car. SAE 1020 and 1025 are not as yet generally used in structural applications, but mention of them is included here in the belief that they may suggest something to a designer.

A bus body builder, who was looking for a rectangular steel tube with a high fatigue resistance for side posts, finally decided on an analysis with a 1.00 to 1.40 per cent manganese content which otherwise was similar to SAE 1010 in its chemical make up. The low carbon in this material makes for high elongation and a high impact strength.

Electric resistance-welded tubing is available in copper-bearing steel and also in pure iron with which is alloyed copper and molybdenum. These materials have been used extensively in the construction of pressure vessels and to some extent in structural applications to resist corrosion and thus obtain longer life.

Still another material of which electric resistance-welded tubing is made is a high tensile low alloy steel developed for the express purpose of providing a stronger material for members; this is now available in a limited range of sizes and gages.

The stainless alloys of the chrome-nickel family have not found their way into the field of structurals extensively in tubular form because of their comparatively high cost. They do, however, present to the designer who is concerned with strength undiminished by corrosion, a material which will answer his purpose as well as give enduring finish. The 18-8S analysis has been used in tubing for applications such as cafeteria trayslides, stairway railings, chairs and railroad seats.

Electric resistance-welded tubing is also made of rerolled railroad rails. In the manufacture of this product a departure from the usual procedure is made at the very start. The rails are broken into short lengths, after which they are rolled into strip and then into a butted tubular shape all in one heat. This butted tube is then welded. If a shape other than round is desired a round tube is heated and rolled into the required form. This material has a carbon range from 0.035 to 0.085 per cent depending on the analysis of the rail used.

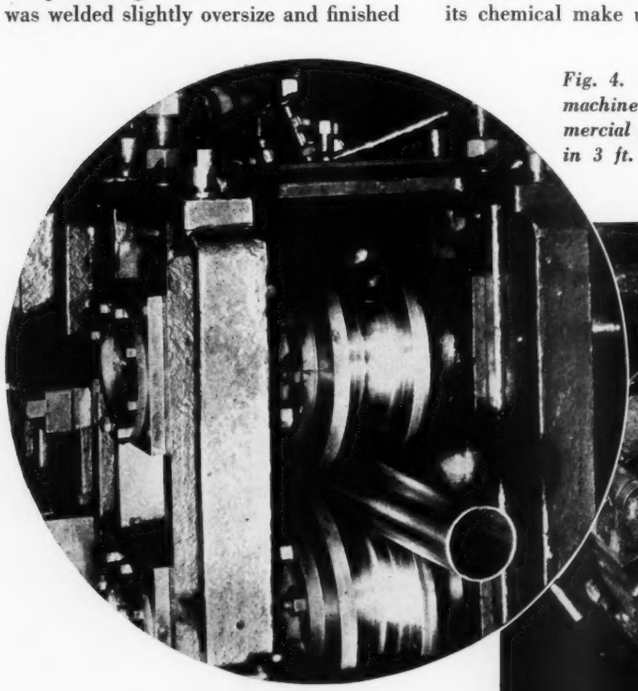


Fig. 4. Below—Straightening machine which holds commercial tolerances of 1/32 in. in 3 ft. linear run of tubing

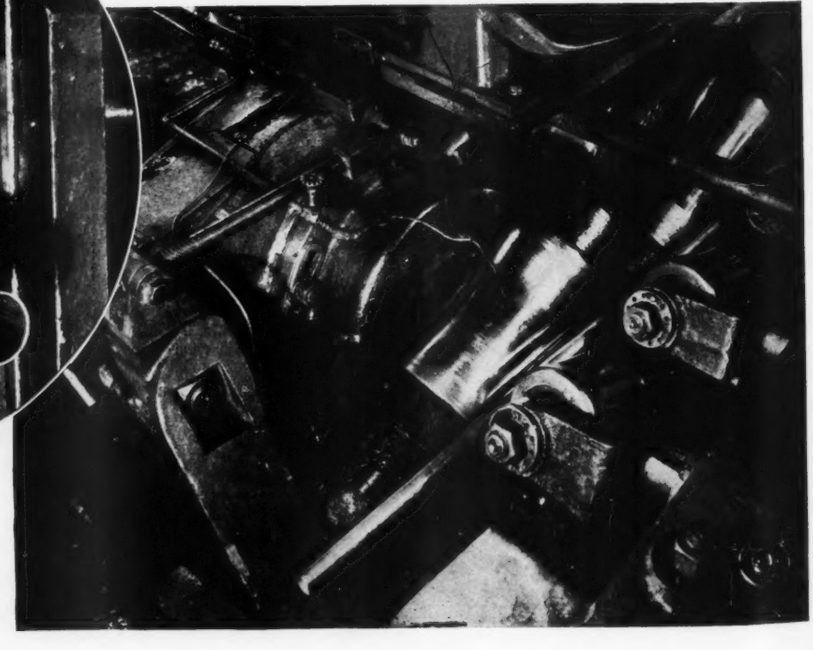


Fig. 5. Above—Sizing and rough straightening rolls, the last unit in a continuous machine which starting with flat rolled stock forms, welds and sizes as successive integral operations

PREDICTING HEAT RISE

On Electrical Machinery

A. F. PUCHSTEIN and T. C. LLOYD
Robbins and Myers, Inc.

Time, labor and power are saved by using a method that estimates the maximum value of temperature rise from data obtained in a short heat run which determines the time-temperature curve

IN MAKING heat runs on electrical machinery, it is frequently desirable to obtain a value for the approximate temperature rise to be expected without being obliged to continue the run over the entire period required for the temperature to become constant. To reduce the running time, the machine may be heavily overloaded until it about reaches the temperature expected and then the load reduced to normal until the temperature remains practically constant. To save on the power costs inherent with this method, several substitute schemes have been suggested. Artificial means of loading, "pumping-back" or "opposition-run" methods are adequately described in technical literature, and highly mathematical analyses of heating phenomena have been made whereby temperature rise can be predicted. For many purposes such methods and analyses are useful, but for routine tests on smaller machines, temperature rise by thermometer and resistance measurements is usually obtained through direct loading.

The following paragraphs describe a method for estimating the final temperature rise from the results of a short heat run. It is suitable for those cases in which extreme accuracy is not needed. The principle is not new, but it is believed that the time and labor saving arrangement will be of interest. The underlying principle is: since the temperature rise is a well known mathematical function with respect to time, the determination of the temperature after a brief period of operation contrasted with the temperature rise at half of that period, fixes the time-temperature curve so as to enable its maximum value to be predicted.

TABLE I

Test Readings on Heat Run of 3 Hp. Motor

Time Minutes	*Room Temp. deg. C.*	*Frame Temp. deg. C.*	*Temp. Rise deg. C.*
0	24.0	...	...
65	26.0	47.5	21.5
120	28.0	58.0	30.0
180	29.0	63.5	34.5
260	29.5	67.0	37.5
305	29.8	68.5	38.7
350	29.8	69.5	39.7

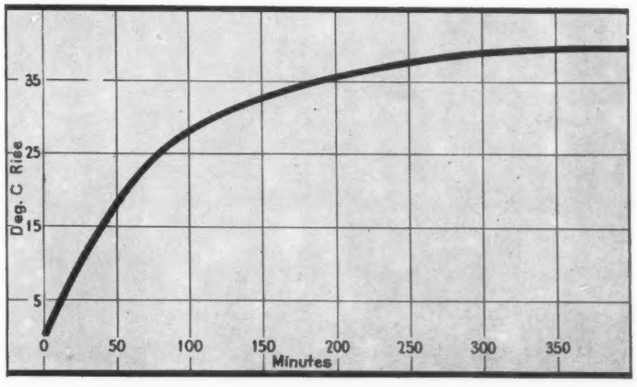


Fig. 1 — Graph plotted from observations taken during a heat run test on a 3 hp. induction motor with thermometers on frame

Method of Procedure

To illustrate the method, consider the data shown in Fig. 1 and Table I taken from a typical heat run made on a 3 hp. induction motor. Although the test was continued until the temperature was practically constant, it will be assumed that it was discontinued after two hours. At the end of this time, the rise was 30 deg. C. above the room temperature. At the end of half of this time or one hour, the temperature rise was 20.2 deg. C. above the room temperature.

$$\text{Temperature ratio} = \frac{\text{Rise in deg. C. at half period}}{\text{Rise in deg. C. at complete period}} = \frac{20.2 \text{ deg. C.}}{30.0 \text{ deg. C.}} \text{ or } 0.673$$

This ratio is used to obtain the factor l in Fig. 2 on the appropriate curve. For this example when the ratio is 0.673, l is 0.508 as read from the curve.

The final temperature rise will then be:

$$\frac{\text{Rise in deg. C. at half period}}{l} = \frac{20.2}{0.508} \text{ or } 39.7 \text{ deg. C.}$$

Since the heating test was actually completed this predicted value can be compared with that obtained by test. The two are identical, but in general such accuracy can not be expected consistently. Checks made on a number of motors indicate that predictions can be made within sufficiently close limits, say a few degrees. Heat runs made with a view of obtaining accurate figures are often illusory anyway because the con-

TABLE II

Coefficients for Time-Temperature Calculations

Per cent of Final Temperature	*Factor in Time Equation*
0.70	1.205
0.75	1.387
0.80	1.610
0.85	1.896
0.90	2.300
0.95	3.000
0.97	3.510
0.99	4.610
1.00	....

ditions of test and use do not always coincide, and because of the unaccountable variations which are inherent in individual machines.

To obtain the most accurate results, it is necessary that the two temperature readings be taken with care and that they cover a period which is a sufficiently large part of the total heating period. For example, large heavy machines may require 10 or 12 hr. for the temperature to reach a steady value, and temperature readings at the end of 30 and 60 min. can not be depended upon to give accurate predictions. On the other hand many fractional horsepower motors reach a steady temperature after a few hours of full load operation. In such machines temperature readings at 30 and 60 min., or even 15 and 30 min. cover a sufficient period to apply this method with assured success.

The heat run plotted in Fig. 1 was made with thermometers on the motor frame. The procedure is also applicable to temperature calculations for the windings or core.

Time for Test Load

Although the use of the temperature ratio and the factor *l*, yields the final temperature, no indication has yet been given as to how long the machine would have to be operated at its test load before this temperature rise would take place. This calculation can be disposed of in the following manner.

Mathematically the theoretical expression for heating is such that the temperature continues to rise slowly for an infinite time. Actually the time required to reach say 95 or 98 per cent of the final temperature is sufficiently significant. Calculation can then be made as follows:

To reach 95 per cent of final temperature the time in minutes is:

$$3.00 \times \left(\frac{\text{Minutes of heating interval}}{k}\right)$$

where k is read from Fig. 2 for the ratio of temperatures.

Then in the example previously considered:

Ratio $= 0.673$

$k = 1.44$

Minutes of heating interval $= 120$

Time for 95 per cent

$$= \frac{3.00 \times 120}{1.44} \text{ or } 250 \text{ minutes}$$

Reference to the test curve indicates that the motor had a temperature rise of 37.8 deg. C. in 265 minutes instead of the 250 minutes predicted.

Because motors are frequently used on definite duty cycles involving a limited period of operation, temperature rise at the end of some definite period is of importance rather than the final value. To determine the time required to reach some temperature other than 95 per cent of the final value, it is only necessary to change the factor 3.00 as used above, using instead the values given in Table II. These calculations are inclined to be much more accurate for reduced time periods corresponding to temperatures below 95 per cent of normal, because of the increased slope of the curve.

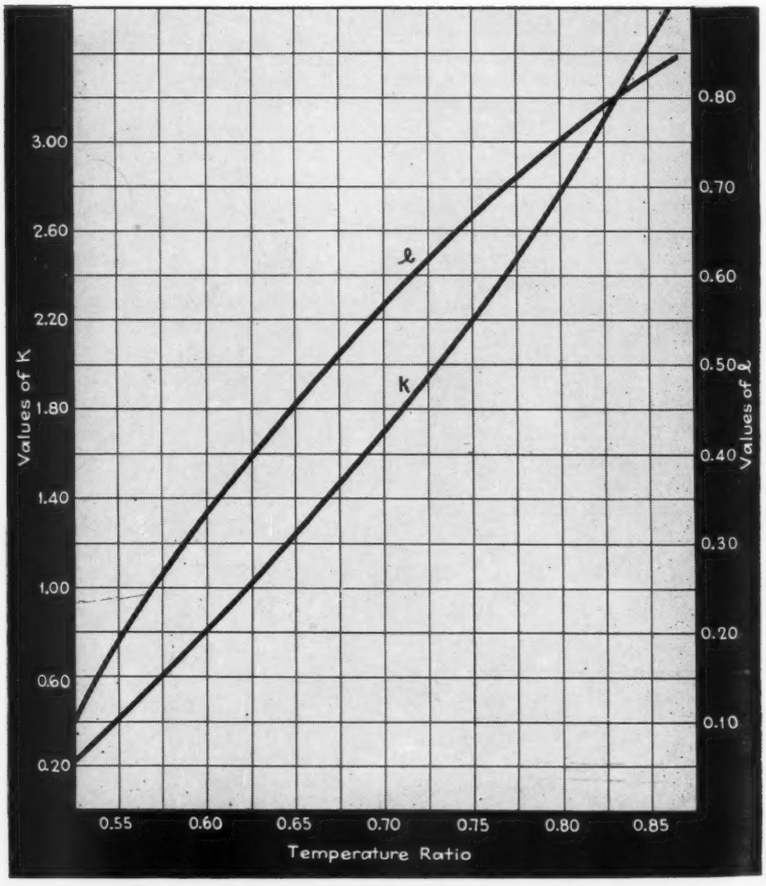


Fig. 2—Curves for determining the numerical value of constants for particular values of the ratio of temperatures

COORDINATION OF DESIGN

Throughout Product Development

From the origin of the idea for a new product to its final release to the factory, every step in the development work of the International Business Machines Corporation is integrated by cooperative action

ALTHOUGH the International Business Machines Corporation manufactures a varied line of business machines at Endicott, N. Y., they are put through in lots of such moderate size that the factory is not departmentalized according to product. On the contrary each manufacturing department produces parts for all of the different machines, with the exception of the electric typewriter which is built in a plant at Rochester. As a consequence unusually close attention has to be paid to the coordination of design and manufacturing.

Design and engineering, which includes research and testing, report to the engineering assistant to the vice president in charge of manufacturing. In the engineering department there are approximately 300 engineers, 100 of them on active development work. Their offices, drafting rooms, model rooms, laboratories and technical library are housed in an air-conditioned building, colonial in architecture. Each of the development engineers has his own office, model room and drafting room where he can carry on his work undisturbed.

In the field, the corporation maintains a force of efficient customer service men who are constantly on the alert for suggestions that may lead to additions to the line of products, or to modifications and improvements in the existing line. They study customer needs and report their findings to headquarters.

When a suggested new product or improvement has proceeded far enough to warrant it, specifications are drawn up and are put before a Future Demands Committee. If approved they go back to Endicott and are assigned to a development engineer whose job it is to work out a design that can be built within the cost set by the committee.

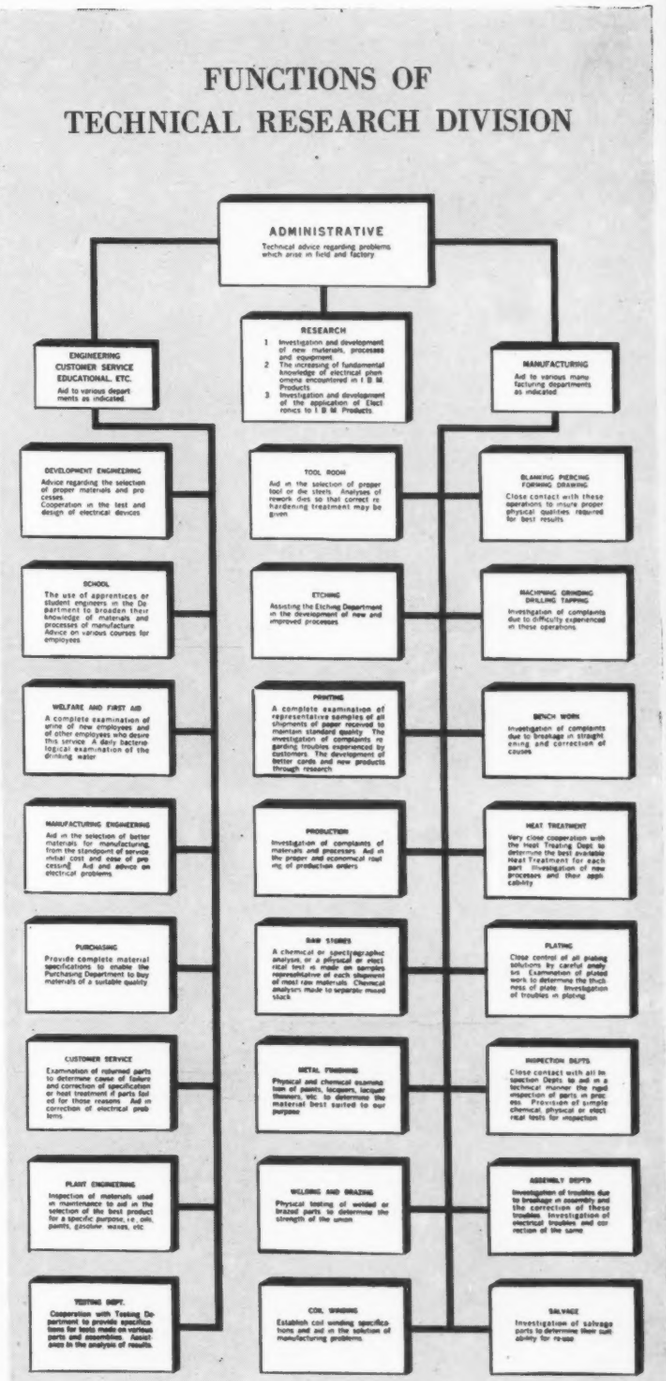
If the engineer is able to produce a layout that looks promising it is submitted to another committee, made up of the manufacturing vice president, his engineering assistant, the manufacturing engineer and the field man who sent in the original suggestion.

Upon approval by this group a model is started. Most of the parts are made in a special machine shop where special devices and attachments for customers' machines are constructed.

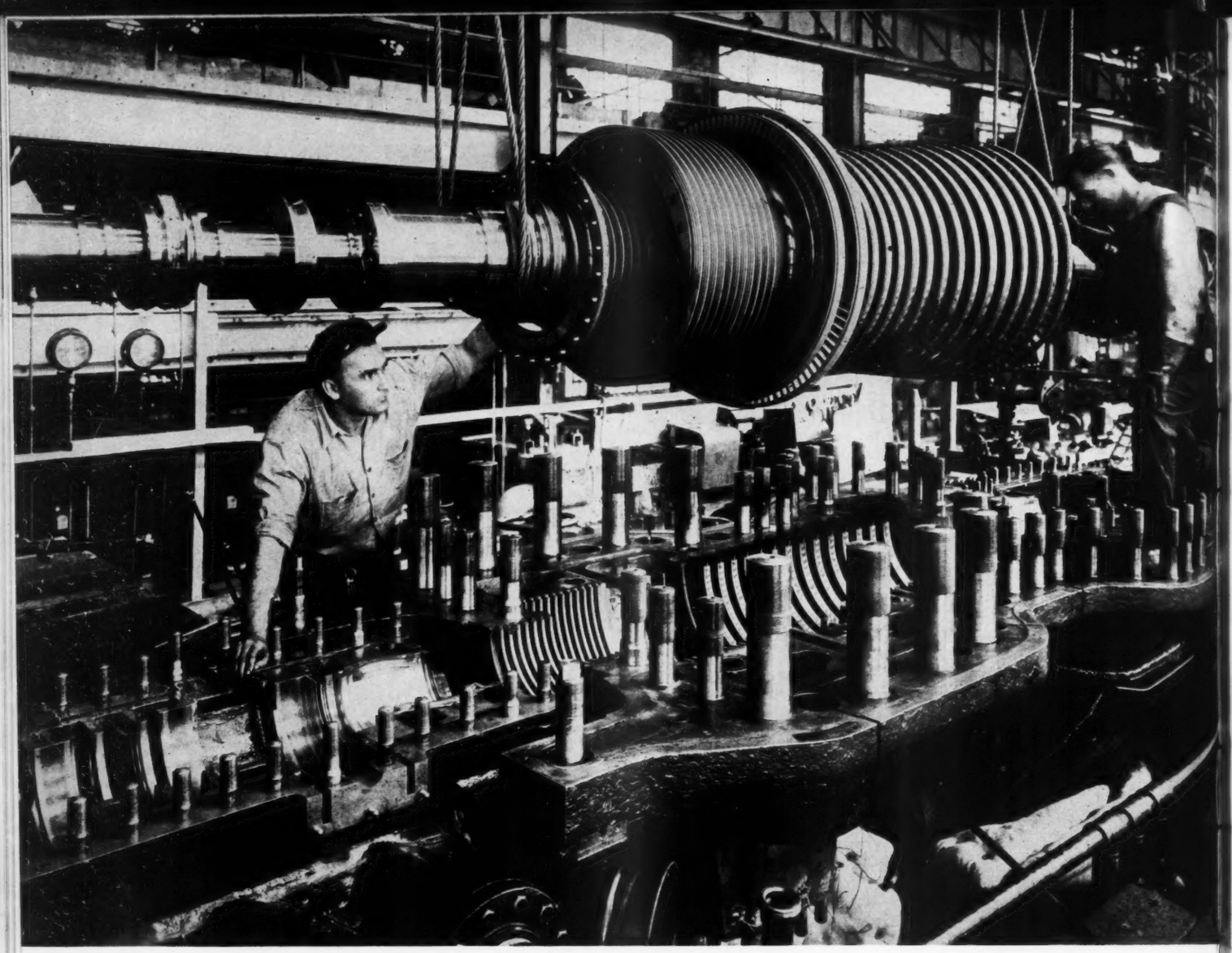
After a satisfactory model has been produced the patent department checks for interferences, and the manufacturing engineer goes to work to develop a production design. Necessary compromises between design and economical production are worked out, and the job is tooled. Occasionally potential difficulties indicate the wisdom of building one or more production models. If this is done the development engineer usually takes one of them into the field to watch its performance.

In the testing division, which operates under the direction of the engineering assistant, most of the work done is of the accelerated or break-down type. Parts and complete machines are tested under simulated field conditions, and under abnormal conditions of high and low voltages, speeds and temperatures to determine their durability.

The director of technical research is in touch with the project during its development because all materials used must have his approval. The electrical laboratory may also be called upon for advice on matters within its province. A chart developed by I.B.M.'s director of technical research is reproduced here to show the many cooperative functions of such a division in a modern industrial organization.


FUNCTIONS OF
TECHNICAL RESEARCH DIVISION
ADMINISTRATIVE
Technical advice regarding problems which arise in field and factory.
RESEARCH
1 Investigation and development of new materials, processes and equipment
2 The increasing of fundamental knowledge of electrical phenomena encountered in I B M Products
3 Investigation and development of the application of Electronics to I B M Products.
ENGINEERING CUSTOMER SERVICE EDUCATIONAL, ETC.
Aid to various departments as indicated.
MANUFACTURING
Aid to various manufacturing departments as indicated
DEVELOPMENT ENGINEERING
Advice regarding the selection of proper materials and processes
Cooperation in the test and design of electrical devices
TOOL ROOM
Aid in the selection of proper tool or die steels. Analyses of rework dies so that correct re hardening treatment may be given
BLANKING PIERCING FORMING DRAWING
Close contact with these operations to insure proper physical qualities required for best results
SCHOOL
The use of apprentices or student engineers in the Department to broaden their knowledge of materials and processes of manufacture
Advice on various courses for employees
ETCHING
Assisting the Etching Department in the development of new and improved processes
MACHINING GRINDING DRILLING TAPPING
Investigation of complaints due to difficulty experienced in these operations
WELFARE AND FIRST AID
A complete examination of urine of new employees and of other employees who desire this service. A daily bacteriological examination of the drinking water
PRINTING
A complete examination of representative samples of all shipments of paper received to maintain standard quality. The investigation of complaints regarding troubles experienced by customers. The development of better cards and new products through research
BENCH WORK
Investigation of complaints due to breakage in straightening and correction of causes
MANUFACTURING ENGINEERING
Aid in the selection of better materials for manufacturing from the standpoint of service obtained cost and ease of processing. Aid and advice on electrical problems
PRODUCTION
Investigation of complaints of materials and processes. Aid in the proper and economical routing of production orders
HEAT TREATMENT
Very close cooperation with the Heat Treating Dept to determine the best available Heat Treatment for each part. Investigation of new processes and their applicability
PURCHASING
Provide complete material specifications to enable the Purchasing Department to buy materials of a suitable quality
RAW STORES
A chemical or spectrographic analysis, or a physical or electrical test is made on samples representative of each shipment of metal raw materials. Chemical analyses made to separate mixed stock
PLATING
Close control of all plating solutions by careful analysis. Examination of plated work to determine the thickness of plate. Investigation of troubles in plating
CUSTOMER SERVICE
Examination of returned parts to determine cause of failure and correction of specification or heat treatment if parts failed for those reasons. Aid in correction of electrical problems.
METAL FINISHING
Physical and chemical examination of paints, lacquers, lacquer thinners, etc. to determine the material best suited to our purpose
INSPECTION DEPTS
Close contact with all inspection Depts to aid in a technical manner the rapid inspection of parts in process. Provision of simple chemical, physical or electrical tests for inspection
PLANT ENGINEERING
Inspection of materials used in maintenance to aid in the selection of the best product for a specific purpose, i.e. oils, paints, gasoline waxes, etc
WELDING AND BRAZING
Physical testing of welded or brazed parts to determine the strength of the union
ASSEMBLY DEPTS
Investigation of troubles due to breakage in assembly and the correction of these troubles. Investigation of electrical troubles and correction of the same
TESTING DEPT.
Cooperation with Testing Department to provide specifications for tests made on various parts and assemblies. Assistance in the analysis of results.
COIL WINDING
Establish coil winding specifications and aid in the solution of manufacturing problems.
SALVAGE
Investigation of salvage parts to determine their suitability for re-use

Activities of I.B.M.'s technical research division tie it and the development engineering staff, with which it is affiliated, in with the work of diverse other units of the company.



MODERN MECHANICAL DESIGNS

50,000 KW Steam Turbine Being Built by Westinghouse

COMPLETE unit consists of two turbines connected in tandem and driving a single generator, a direct-connected exciter and a pilot exciter. The illustrations show the main turbine. It is a single cylinder, combination Curtis and reaction machine of the high pressure, non-condensing type. Normal speed is 3,600 r.p.m. The main turbine is designed to operate at 1,200 lb. per sq. in. steam pressure; the inlet temperature is 900 deg. F. at this pressure.

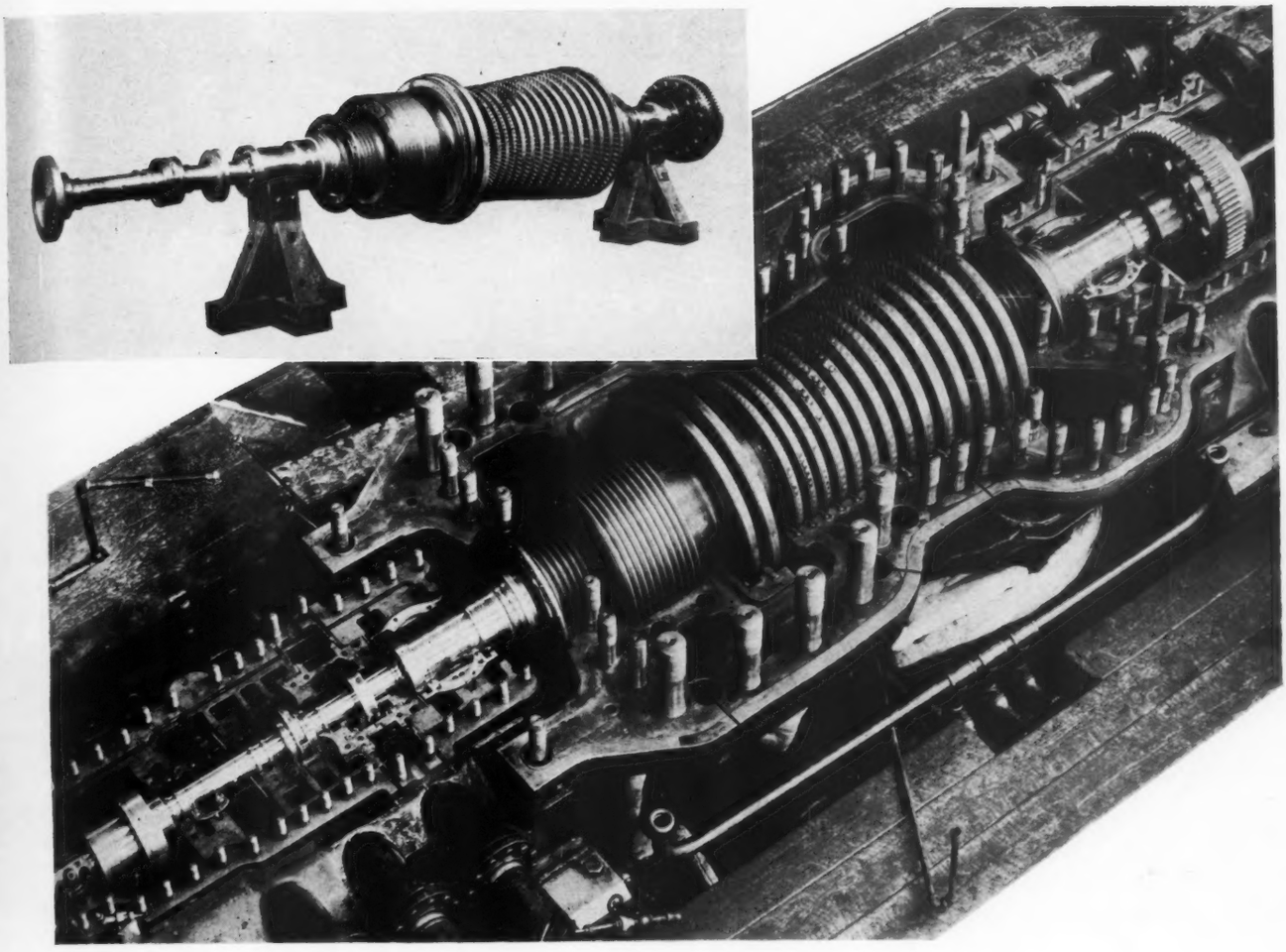
The main turbine cylinder is made of cast carbon molybdenum steel and is split in the horizontal center plane to form a base and cover. Blade ring elements are cast integrally. An important feature of the cylinder design is an annular steam belt extending around the entire cylinder at the high pressure end to equalize the temperatures of the base and cover thus decreasing the possibility of cylinder distortion. This chamber serves as the steam passage between the inlet valve, located in the cover, and its nozzles located in the base, and therefore is filled completely with steam as soon as the valve is opened.

The base and the cover of the main turbine cylinder are bolted together by large studs made of chromium molybdenum steel which are pre-stressed at assembly to compensate for thermal expansion. The material has low creep at high temperatures.

To obtain higher unit pressures on the joint the central portion of the cover flange face is recessed. To relieve thermal stresses in the thick flanges they are cut with transverse slits to a depth determined by the location.

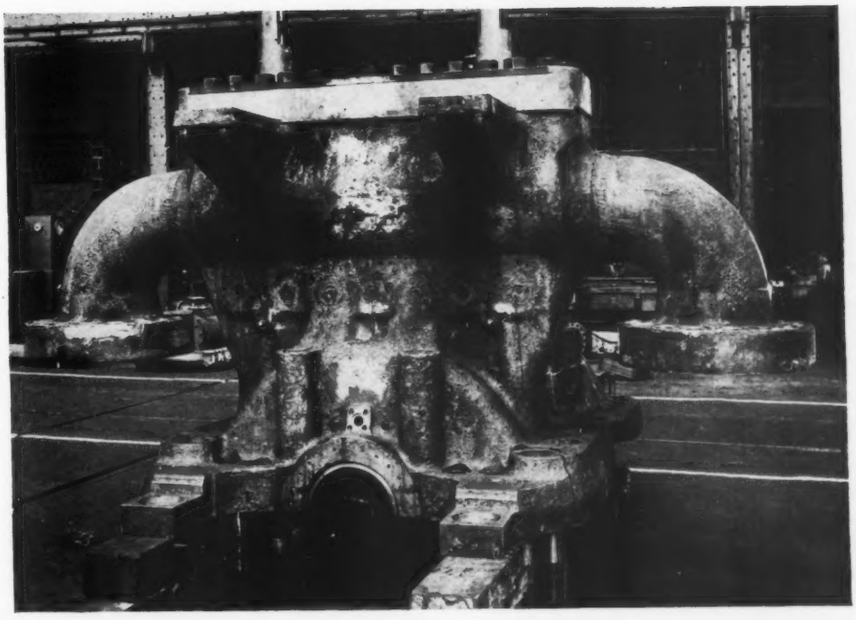
The turbine rotor is machined from a solid forging of nickel chromium molybdenum steel to withstand the high inlet temperatures. Chromium steel bar is used for all blading.

Provision is made in the method of supporting the entire unit to allow the



various parts to expand and contract without causing distortion. The main turbine cylinder is supported by four arms or lugs which are cast integrally at the top of the base with the point of support close to the horizontal centerline. These arms rest on separate pedestals on which they are free to slide, being held only loosely by bolts.

At each end, the cylinder is connected to the pedestal by a single vertical pin placed on the longitudinal centerline, thus maintaining the correct axial and transverse position of the cylinder with relation to the pedestals. The exhaust end pedestal is anchored to the foundation seating plates by keys and gibs and serves to anchor the entire unit. The inlet end pedestal is free to slide axially on its base, but is held against transverse movement by an axial key, placed on the longitudinal centerline, between it and the base. Any tendency to tilt is limited by fitted side gibs.



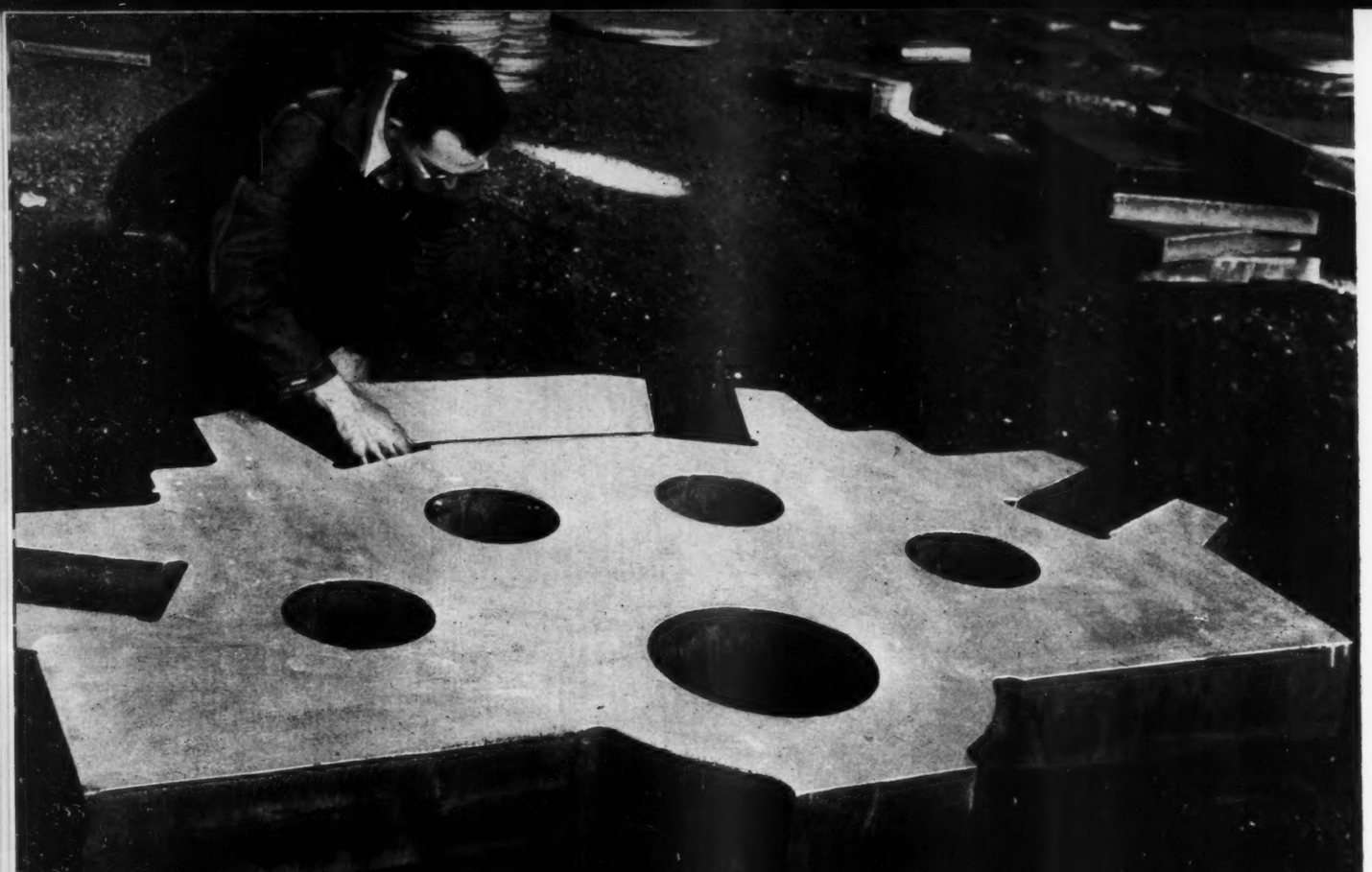


Fig. 9—Flame-cut frames for a four-color sheet-fed printing press manufactured by C. B. Cottrell & Sons Company. These frames not only support the impression cylinder and the four plate cylinders, weighing a total of about 9½ tons, but are also subject to the forces developed by the printing pressure and the drives. In this design the finished steel frames cost more than cast iron frames of the same size, pattern costs included, but the greater rigidity of the steel frames was considered worth more than the difference in costs

SHALL IT BE WELDED?

If So—How Designed?

E. J. CHARLTON
Engineer, Lukenweld, Inc.

Part II—In this concluding installment the author shows how good design practice may frequently call for a combination of forgings, castings, and formed plates; he emphasizes the possibilities of flame cutting and warns against attempting a welded design that is expected to come exactly true to shape

BASIC PRINCIPLES of design are always the same regardless of the type of construction to be used. Be it a casting, forging, welding or any other construction, the finished part or structure must have the required strength and rigidity, uniform stress distribution including the absence of points of stress concentration, and proper provisions for connecting it to its other parts. The type of construction will dictate the provisions that must be made in the design in order that these objectives will be attained. In the case of welding, the design must be studied with reference to the sequence of assembly of the pieces and their positions in order that all joints will be accessible for welding. In addition, the character of the stresses on the welds and the manner in which it will be stressed must be established.

As the welded design proceeds, the possibilities of using various different methods of construction in combination with welding should always be kept in mind. Flame cut parts, formed or rolled parts in combination with castings offer many possibilities.

Little need be said about the cutting torch and its applications. Figs. 9, 10 and 11 show some interesting examples of what can be produced readily from thick plates cut with a torch. Such pieces function as individual parts of

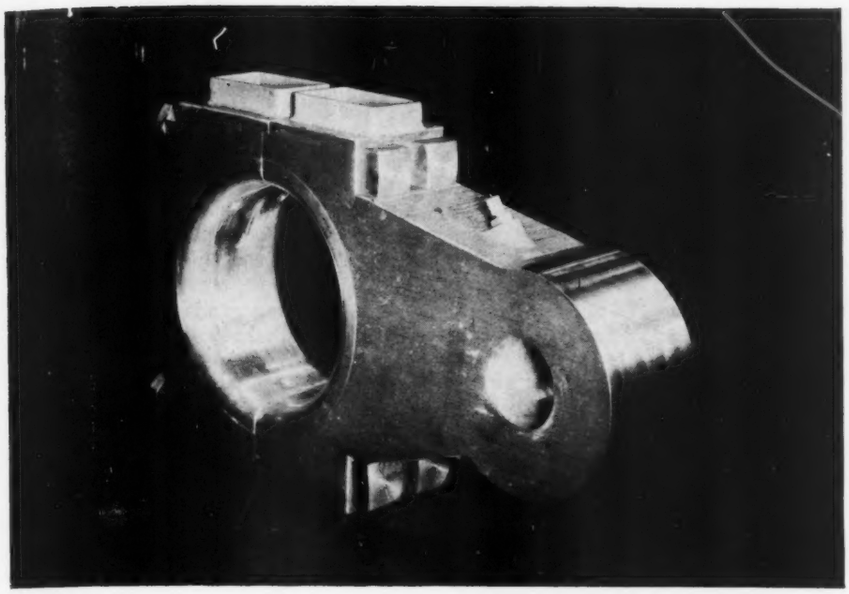


Fig. 10—Pitman and cap, or main connecting rod, for an Ajax upsetting forging machine. The lugs for oil cup and set screws are welded on. Made in various sizes, these pitmans are flame-cut from plates ranging from 3⅜ in. to 9⅞ in. thickness

machines and may not involve any welding whatsoever. In some instances it will be found not only economical but also better from the technical design angle, to flame-cut the part from a thick plate rather than making it by welding a number of pieces together.

In applications of torch-cut plates some designers show a tendency to call for only straight edges when using steel plates. This has probably come about by thinking of steel plate in terms of warehouse stock and the shaping limitations of the plate shear. However, today the average steel warehouse has and uses flame cutting equipment.

Thought and ingenuity can be applied to the maximum utilization of scrap resulting from flame-cut parts. An accumulation of plate stock of diversified sizes is a natural outcome of fabrication by means of the cutting torch and welding electrode. There is no good reason why many pieces of a given gauge, left over after a plate has been flame-cut to the desired shape, cannot be restored to this stock for use on a future job.

Considering the function of forming and rolling equipment as accessories to welded steel production, Fig. 12 shows an interesting design of hydraulic press frame. The merits of this piece from the standpoint of production simplicity and deflection characteristics, a major factor in such frames, are readily seen. The stabilizing box section members seen at the sides of this frame are formed on the bending brake. As mentioned previously plates formed by such methods, within certain size limits, are readily available.

The upper charging box of the two shown in Fig. 13 is a good illustration of the diversity of equipment and materials that might contribute to a welded assembly. In this job is a steel casting

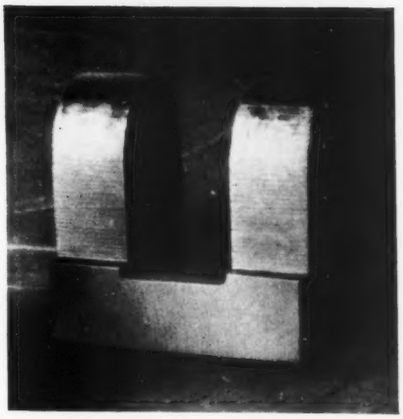


Fig. 11—A good example of "two-direction" flame cutting. No welding was done on this part which was cut from a solid block about 12 in. long, 7 in. wide and 12 in. high

forming the more complicated portion, a U-shaped bent plate which serves as the main portion of the box, a die formed piece on the front end and a rolled steel bar along the edges.

Similarly, forgings or castings are generally used for large cylindrical bearing housings and other machine elements wherein the functional requirements necessitate a massive shape; strong fillets of large radii are needed; or lips, reinforcing ribs and other surface irregularities are desired or necessary to get the best proportions and the best distribution of metal. In this connection, it must also be considered that for certain parts, to produce the shape desired by flame cutting may not be economical for that particular part whereas the pattern cost or forging-die cost for a relatively simple shape may be comparatively inexpensive, especially when an appreciable number of pieces are to be made.

Frequently a compromise between a casting and structural welded piece represents the best design practice. Thus it may be better engineering to redesign an integral cast bearing housing and pedestal, making the bearing housing a steel casting and the pedestal of welded plate construction. Such a composite design has many inherent advantages.

As a generality it can be said that when a casting embodies surfaces of broad expanse and relatively thin section, such portions of the casting can be economically and otherwise advantageously replaced by structural plates welded to the remaining cast portions on which lips can be provided to facilitate the welding, and cast or forged fillets provided where desired.

Similarly, if the quantities involved are such that the making of a forming die

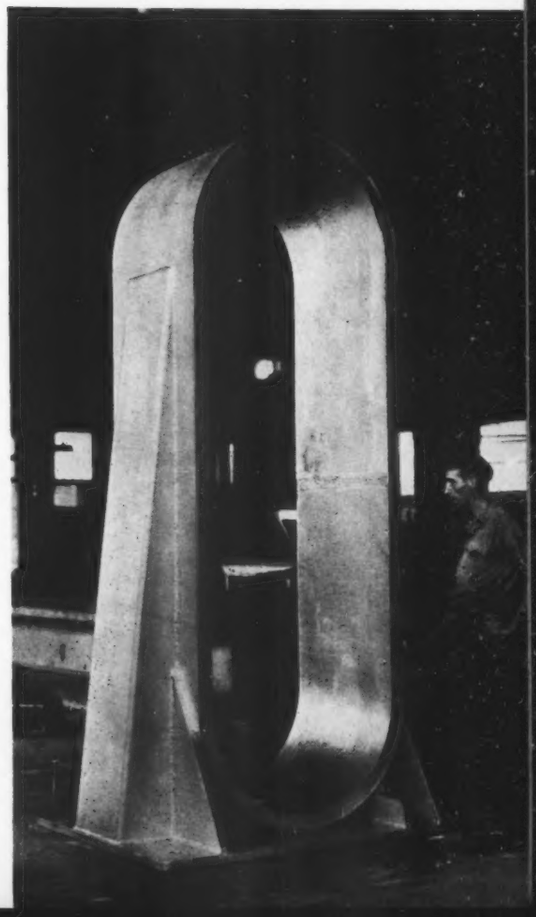


Fig. 12—An interesting design of a frame for a 2,100 ton hydraulic press, fabricated by Lukenweld for Stewart Bolling & Company. Advantages claimed for this type of frame are equal tension on both sides of the frame, absence of bolts and nuts, and alignment does not depend on machined surfaces

is economically justified, pressed or formed pieces might be used for certain portions of the structure. Thus pressed corner pieces, formed heads and similar parts as shown in Fig. 13 can often be used to advantage.

Much has been written with reference to making welded structures come exactly true to shape. Whenever heat is applied locally, the shape is bound to distort or warp. Therefore, in every design of a welded structure, the design should be laid out so that warpage to a slight degree will be permissible. Very often the design can be worked out with thought so that the amount of warpage that does occur will effect the critical dimensions a minimum amount. An example of warpage is in the design of two plates welded together to form a T-section as shown in Fig. 14. If the plate is welded on both sides as shown in the sketch, the top flanges are bound to show a tendency to bend as indicated.

A nicely balanced design is one that utilizes the available construction methods and materials to best advantage. But regardless of the method or material, the fundamental principles of mechanical design will always apply. Be it a casting, forging or welded part, sharp corners

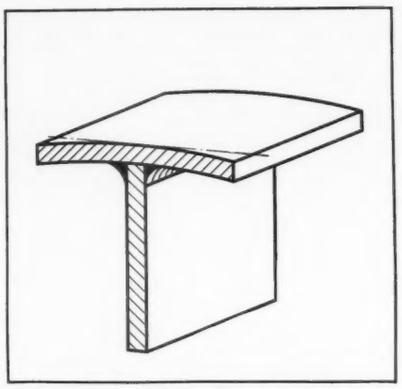


Fig. 14—If two plates are welded together to form a T-section as shown here, the top flanges are bound to show a tendency to bend as indicated because the localized heating and expansion will develop unbalanced internal stresses

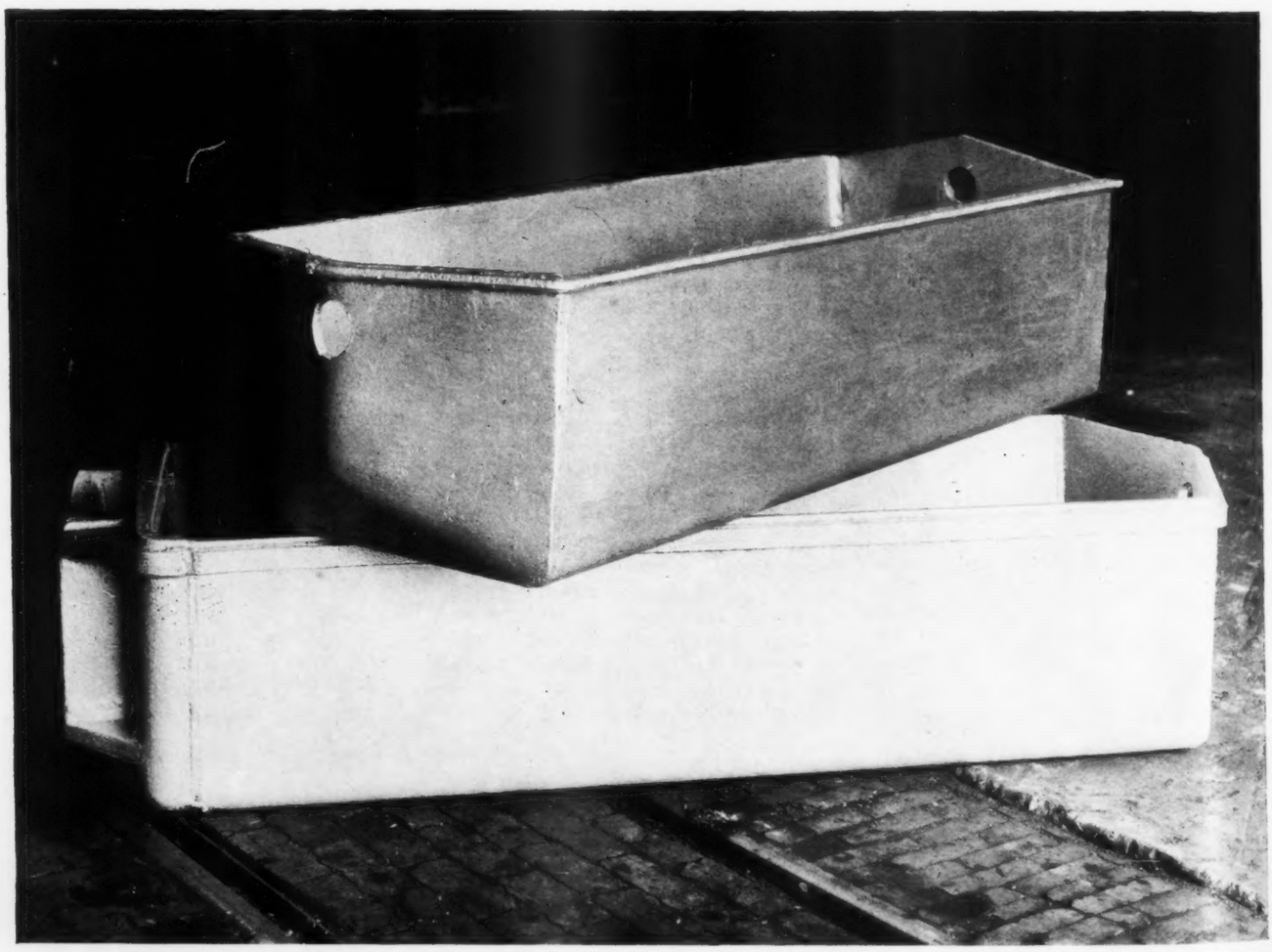
and abrupt changes in cross section induce stress concentration, eccentrically loaded joints produce bending moments, thermal stresses induce distortion, and a design that ignores the appearance factor looks like a monstrosity.

Criticism of a poor design in welding is sometimes met with the retort that it is "good enough" for a particular function. The fact that accidents, tending to impose a strain greater than that of normal duty, have never occurred in the machine is no insurance against their future occurrence.

Welded steel has found its place in industrial mechanisms. Undoubtedly in some applications it has been misused but on the other hand there are those who, admitting its superior metallurgical and engineering qualities, challenge one to demonstrate the inadequacy of the materials they are using in their particular application and declare that added sturdiness with less or equal weight, imparted to their machine by the use of a superior material, is unnecessary. Cost factors remaining equal, no material is too good for a given function.

It is not expected that the design suggestions given in this article are all inclusive or complete. They merely serve to point out some of the factors that should be considered. Works of art cannot be created by blindly following rules, nor can an efficient design be developed by rules of thumb.

Fig. 13—Welded steel charging boxes. These designs indicate the diversity of equipment and materials that might contribute to a welded assembly



Question and Comment

More on Charts for Proportioning Shafting

To the Editor:

In the Question and Comment section, page 189, of your May issue, Mr. Salvatore F. Cavalli presented a nomogram for shafts subject to torsion. In our opinion there is no virtue in his introducing the constant K, and the chart should plot the following equation:

$$H = \frac{Sd^3N}{322{,}000}$$

H = hp. transmitted by shaft
S = allowable stress, lb. per sq. in.
N = speed of the shaft in r.p.m.
d = shaft diameter in in.

In Mr. Cavalli's Fig. 1, the formula uses R in place of N and the graduation of the d-scale starts with 1, instead of 0. However, the above equation, which eliminates the need for his Fig. 2, still plots similarly to his Fig. 1 and is a double-Z chart with a diagonal turning scale, as shown in Fig. 1 herewith.

The basic formula, with four variables involving only multiplication and powers, can be charted in several different ways. For that reason, many readers may be interested in a comparison of various nomograms for this equation, as shown in the accompanying sketches and discussed in the following paragraphs.

Figs. 1 and 2 do not use logarithmic graduations and each requires two computing secants as shown by the dotted lines. The proportional scales, although easy to interpolate, have either a small range or a large error at low values. Fig. 1, as stated, is similar to Mr. Cavalli's Fig. 1. Fig. 2 may be regarded as Fig. 1 with double graduations removed by the device of rotating one of the superposed scales through 90 deg. For Figs. 1 and 2 the form of the equation used, letting c = 322,000 must be:

$$\frac{cH}{S} = \frac{1/N}{d^3}$$

The scale equations for either chart are:

$$x = m_1cH \qquad y = m_2S$$
$$z = m_3d^3 \qquad u = m_4(1/N)$$

Also, $m_1/m_2 = m_3/m_4$

x, y, z, and u = distances along the H, S, d, and N scales respectively.

m_1, m_2, m_3, and m_4 = moduli or lengths of units for the H, S, d, and N scales respectively.

This same formula can be plotted as a double-Z chart, Fig. 3, singly graduated with a parallel turning scale graduated as torque T. The formula is thus broken usefully, so that:

$$T = \frac{\pi Sd^3}{16} = \frac{63{,}100\,H}{N}$$

Fig. 4 is a square nomogram using logarithmic graduations. It has the advantage, in common with Figs. 5 and 6 which also have logarithmic scales, of a large range of the variables and the same percentage error at any point. It avoids acute intersections and is the only form of nomogram that will solve this equation of four variables at a single setting, the solution being conveniently found by means of a cross-hair templet drawn on transparent paper. For Fig 4 and Fig. 5, the equation must be in the following proportional form:

$$\frac{1/d^3}{N} = \frac{S}{cH}$$

The scale equations for each side are:

$$x = m(\log H + \log c) \qquad y = m \log S$$
$$z = m(-3 \log d) \qquad u = m \log N$$

In these scale equations, x, y, z, and u are distances along the scales as before, and m is the length or modulus of the logarithmic scale from 1 to 10 in the same unit, m being chosen to suit the size of paper and the range desired. The minus sign in the z-scale equation indicates that it is plotted in the opposite direction. Fig. 5 may be considered as Fig. 4 with the opposite scales, S and H, rotated anti-clockwise 90 deg. until scale S coincides with d, and H with N. This makes the two computing secants parallel instead of perpendicular.

Fig. 6 is formed of parallel logarithmic scales and requires two calculating secants to be drawn intersecting the central turning scale, but it has the advantage, over Fig. 4 and Fig. 5, of a greater choice in the values of the moduli. The equation is put in the following form:

$$\frac{cH}{N} = Sd^3 = Q$$

Here, Q is introduced to break the equation into two three-variable equations, each equal to Q, which forms a common turning scale. The scale equations are:

$$x = m_1(\log H + \log c) \qquad y = m_2 \log S$$
$$z = m_3 \log d \qquad u = m_4(-\log N)$$
$$v = m_5 \log Q$$

Also:

$$m_5 = \frac{m_2\ m_3}{m_2 + m_3} = \frac{m_1\ m_4}{m_1 + m_4}$$

The scales are spaced proportionally to the moduli as indicated in Fig. 6.

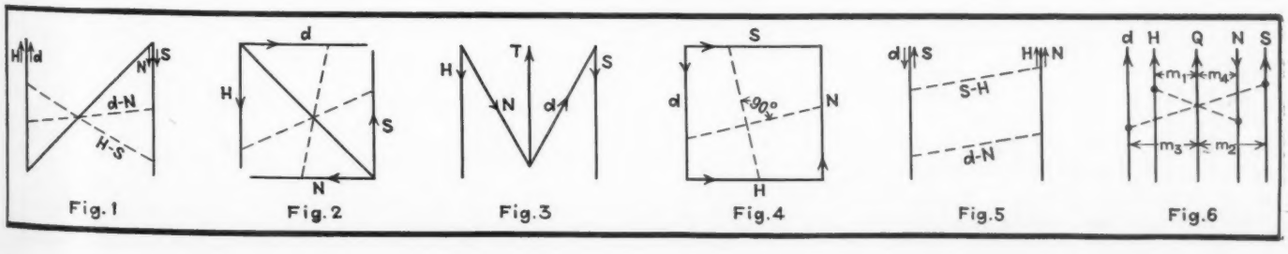
In all of the above instances, instead of carrying the constant, c = 322,000, through as shown, it may be ignored, and the relative position of the graduations found, as for Fig. 4, by assuming three of the scales completely, as well as the modulus of the fourth scale. Then by making a single calculation from the formula a point fixing the graduations of the fourth scale can be determined.

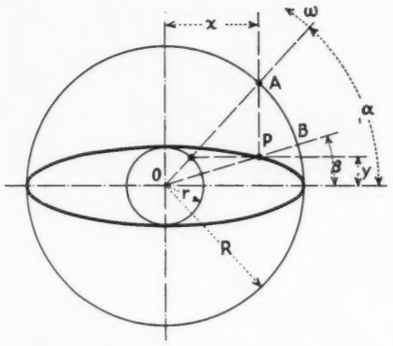
—Carl P. Nachod, *Louisville, Ky.*

Angular Velocity Problem

To the Editor:

A problem is herewith submitted for solution by readers of *Product Engineering* via the Question and Comment de-





Required: An expression for the rate of change β with respect to α at any value of α from 0 to 2π

partment, where the writer has found many interesting problems since the first issue in 1929.

The accompanying diagram shows one of several methods of constructing an ellipse. Auxiliary circles equal to the major and minor diameters of the ellipse are drawn and then a number of rays, such as OA, are then projected from the center.

Where the rays intersect the auxiliary circles, lines are projected horizontally and vertically as shown, and the intersection of these projections is a point P on the ellipse. The angle α is called the eccentric angle.

If the eccentric angle varies from 0 to 2π, the loci of points P will be an ellipse of major and minor diameters $2R$ and $2r$, respectively.

Assuming the line OA to rotate with the constant angular velocity w, at any time wt, the angle α will be wt. At this value of α, if a line, such as OB, be drawn from the center through point P, this line will make an angle β with the axis. It is evident that β does not rotate with constant angular velocity.

What is desired is an expression for $d\beta/d\alpha$, or $d\beta/d(wt)$, that is, the rate of change of β with respect to α at any value of α from 0 to 2π.

— H. W. D'ENTREMONT
East Orange, N. J.

Emulsified Lacquers for Porous Surfaces

L. JAY SMITH
Roxalin Flexible Lacquer Co., Inc.

By the use of a new emulsified-lacquer finish it is now possible to effectively coat porous materials. The lacquer emulsion, which consists of an extremely viscous, dough-like lacquer base dispersed in a relatively small percentage of water, forms a flexible, adherent and attractive surface. Besides having a high film-forming solids content, it permits the use of nitrocellulose of much higher viscosity which, in turn, produces a film of greater strength. Instead of the solvent thinners used for lacquers, the emulsion can be thinned with a small quantity of water.

Almost any type of lacquer with the correct properties and merits for specific jobs can be adapted to emulsification either for producing a finishing material that will permit the application of a heavy single coat, or for producing a surface coating that will not be absorbed by a porous material. The emulsion can be used to finish many types of products which have in the past been considered unsuitable or uneconomical to finish and in many cases it will also improve the existing finish. For example, it can be used to apply a surface film on materials of such extreme porosity as blotting paper which, if unsized, would readily absorb the usual lacquer solution.

Moreover, lacquer emulsion can be made in great varieties by blending it with an emulsion of another material such as wax, and widely different properties can be obtained by blending to produce a final film equal to that of a solution composed of the combined ingredients. For example, it is possible to add resin solutions by stirring them into the emulsion. Wall board or papier mache which is to be covered with paint or varnish will assorb practically none of these materials if first given a light sizing coat of emulsified lacquer.

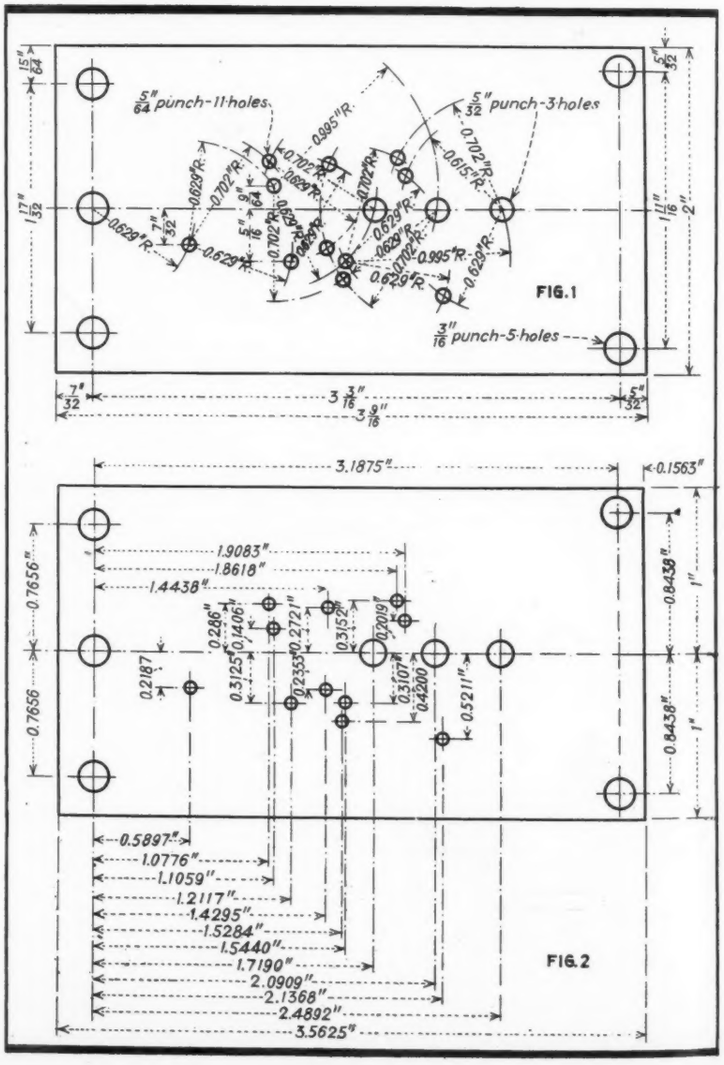
Stepped Dimension Problem

To the Editor:

We have three jig boring machines in constant use in our tool room, and consequently many interesting problems arise in connection with the work.

Recently the sketch shown in Fig. 1 was given us, the problem being to find the stepped dimensions as indicated in Fig. 2. The computations had to be accurate to four decimal places.

I was required to estimate the time required to solve it and guessed four



hours. Was this estimate too high or too low? Fig. 2 gives the correct results, but they were not obtained in four hours. Can anyone inform me if there are short cuts that can be used in handling problems of this kind?

—C. W. HINMAN, *Chicago, Ill.*

Braking A.C. Motors by Direct Current

ARMAND FINLEY
Electrical Engineer
The Reliance Electric & Engineering Co.

An effective method of "dynamic braking" through the action of an electric motor as a brake is being used in connection with the problem of quickly and reliably stopping chucks on the machines in a large aluminum-casting plant. Since the finishing of each article requires only a few seconds, it is important to cut down the time necessary to stop the chuck between conclusion of work on one piece and the insertion of the next.

On the machines originally installed, braking was effected by a clutch and a mechanical brake pedal. It was found, however, that this not only required considerable maintenance but that the stopping time varied according to the degree of wear on the clutch and brake mechanism.

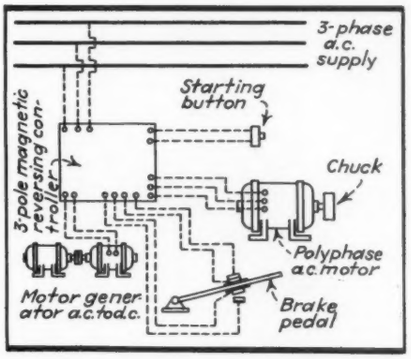
With the new method, the chuck is mounted directly on the shaft of a polyphase squirrel-cage induction motor, controlled by a three-pole magnetic reversing controller. The contact positions of the controller are governed by two solenoids. The one which throws the motor on the a.c. line is operated by a starting button conveniently located on the machine. The other, which throws two terminals of the motor across a source of direct current, is connected to the brake pedal. The accompanying schematic diagram indicates this arrangement.

When the operator presses the button, the motor starts and he begins work. When the piece is finished, he quickly stops the motor by touching the pedal which automatically disconnects the motor from the a.c. line and connects it to the source of direct current. This causes the motor to stop. The controls are so interlocked electrically that the motor will not start when the pedal is depressed.

This method of braking was applied because of its very low maintenance, its smoothness of operation, and the ease of controlling the stopping time. There is no jerking or vibration during braking because the action is electrical and does not depend on mechanical friction.

Furthermore, the stopping time may be easily varied by a rheostat which, when once adjusted, will cause exactly the same braking effort to be exerted during each operation. This is because there is nothing in the braking mechanism that can wear out.

The low-voltage direct current required for this method of dynamic braking is furnished by a small motor-generator set which, in this instance, is capable of delivering enough power for braking eight machines. It is estimated that the arrangement has enabled the manufacturer to increase his production about 20 per cent on each machine.



Schematic diagram of connections between various electric elements used in dynamically braking a motor-driven chuck by applying d.c. to motor

No Optimum Value for Spring-Index

In your July issue, I note, the "optimum value" of 8 for spring index is again under discussion. This value it seems is difficult to eradicate from spring design methods.

Confusion enters this problem only because so many inter-related factors are at work. It can be mathematically shown that only one spring index is possible in any given problem if we have given the maximum fiber stress; maximum working length, L_{max}; minimum working length, L_{min}; maximum corresponding load, P_{max}; and minimum corresponding load, P_{min}. From this definite index (See *Product Engineering* for June, 1934), the actual wire and coil diameters can be obtained. In these computations it is assumed that the most efficient use of space is made.

To enter the discussion, a deliberate decrease in the index below that which is necessary to meet the conditions will increase the maximum fiber stress only if L_{min}/L_{max} and D are the same. Then, however, the corresponding forces P_{min} and P_{max} at these points will change.

Designing springs with small indexes does not necessarily result in the employment of high stresses. It merely limits the ratio L_{min}/L_{max} to a smaller working range for any given value of P_{min}/P_{max}.

The failure of springs with indexes below 8 is not attributable to the index. Springs having indexes above 8 are known to have failed. Failures are caused solely by the stresses in the wire.

The Wahl factor depends upon the spring index but does not influence it, except in so far as it is a stress-concentration factor which must be considered in the general equations for finding the correct spring index for any given problem. The choice of 8, because it is near the knee of the Wahl stress concentration curve, is without foundation because that knee location can be easily altered by changing the scales of either axis of co-ordinates.

Springs having small indexes are dangerous. But the reason can be attributed to nothing other than the variations of physical dimensions either of the spring or of its space, or both, from those theoretically assumed. This can be easily comprehended when we consider that the working range of such springs is relatively small.

When the variations of workmanship approach the total deflection of the spring (as is possible in, for example, sub-press springs), overloads approaching 100 per cent are introduced.

The remedy is simply accurate work, that is, accurately ground spring length and exact control of the movement of the spring in the machine. For any given set of conditions only one spring index is correct and this may vary from below 4 to above 20, as was explained in the issue of P.E. referred to above.

—FREDERICK FRANZ, *New Haven, Conn.*

SOURCES OF SUPPLY WANTED

Here are a number of inquiries that we are putting up to our readers. Answers and information sent in will be forwarded to the individuals concerned and will also be published in the next number:

SNAP-RING MANUFACTURERS

For some time we have been interested in purchasing snap rings described as Type B by Mr. Adam Fredericks in his interesting article on page 189 of your May issue. However, we have been unable to obtain the name of any concern manufacturing this particular type of ring. If any of your readers know such a manufacturer, we should appreciate being advised. —F. M. B.
Milwaukee, Wis.

MAGNAFLUX FILTER

It is the writer's understanding that there is a filter now being manufactured for filtering the ions for plating pro-

cesses. We have need for such a filter to separate Magnaflux powder from coal oil, but have not been successful in finding a filter that is suitable.

We also have been unable to locate the manufacturer of the filter used for separating the ions and would appreciate hearing from any of your readers who could give us the name of this manufacturer or of any manufacturer who makes a product that will successfully filter the Magnaflux powder from the coal oil.

—C. H. B. *Dayton, O.*

FASTENING METAL TO CERAMICS

Because of a new problem, I am very anxious to learn the name of a concern which a year or so ago, if I remember correctly, announced the development of a practical method of fastening metal parts to ceramics, presumably by swaging. Perhaps some of your readers, familiar with this method, will be kind enough to inform me where I can get complete details. —P. K. M.

Cambridge, Mass.

HUMIDITY ELEMENT

In the air-condition indicator which we manufacture to show both temperature and per cent relative humidity, the humidity element is a spiral coil made of soft brass and paper glued together. It is desired at this time either to condense or enlarge the present humidity coil for a new application and, if possible, to change the materials used in making it.

To further this idea we should like to hear from any of your readers who have information available on the composition of humidity elements or have knowledge of some source from which the desired information could be obtained.

—H. F. K. *Chicago, Ill.*

HEAT-RESISTANT FINISH FOR WATER-GAGE INTERIOR

We are interested in obtaining a suitable finish for the interior of a water gage of the flat reflex glass type. The finish is to be applied, under the glass in the steam and water passage, on the bronze or steel walls to give them a black background effect.

Steam pressures are 350, 600, and 1,000 lb. per sq. in. Limiting temperatures exceed the nominal steam-pressure equivalents and reach 450, 600, and 1,000 deg. F. respectively.

We should appreciate learning what data any of your readers may have to offer on heat-resistant color finishes which would be suitable for our use in blackening the water-gage interior.

—H.D.Y. *Detroit, Mich.*

Reducing Friction

JOHN E. HYLER
Peoria, Ill.

Friction, consuming as it does a greater or less part of the power that goes into a machine and leaving just that much less for performance of work, has always been an outstanding enemy of the machine designer.

Modern machinery, of course, is in general more friction-free than that of older days because the accumulated knowledge and experience of past years has been applied to make it so. The constant improvement of anti-friction bearings during late years and their application to practically every kind of machine and mechanism have done more to decrease the friction load than any one thing. In fact, wherever rolling action may logically be substituted for sliding action, inside of a bearing or out, it is worthwhile considering as a means of making more of the delivered power available for work.

However, where one is absolutely limited to sliding action, it becomes important to use such materials as will permit sliding with as little friction as possible. Chromium has advanced into the foreground in this respect, especially in instances where heat is present in connection with a sliding motion, for it is less likely to cut and score if lubrication happens to be faulty than many of the metals that have been used in the past. For example, shafting is being chrome-plated under certain circumstances to make it better adaptable for use in plain bearings, with good results.

Another interesting instance is found in the use of rawhide packing for hydraulic-press stuffing boxes. Rawhide, having the inherent property of becoming very slippery when wet, offers but little resistance to the sliding of the ram and yet makes a splendid packing. By the same token, rawhide packing is also a very good material for dredge or other submarine work.

Doubtless it would be a paying proposition to make a survey of each proposed new machine or mechanism, separate and distinct for the purpose of incorporating every known means of keeping down the friction load and, if possible, of devising further ways and means of accomplishing the same end. Without question there are still many discoveries to be made in this field that will render the machines of the future even more efficient than our splendid machines of today.

Needle-Bearing Formula

LEE WALTHER
Astoria, N. Y.

Recently I had occasion to refer to Mr. K. L. Hermann's formula for the load capacity of needle bearings, published in your April, 1933 issue thus:

$$R = 0.16\,PLC/D\sqrt[3]{S}$$

R = rated safe load, lb.
P = number of rollers
D = diameter of rollers, in.
L = length of rollers, in.
S = speed in r.p.m.
C = constant

The values of the constant C are given as 275, 618, 1,100, 1,718, 2,475, 3,368, and 4,400 for 1/16, 3/32, 1/8, 5/32, 3/16, 7/32, and 1/4 in. diameter rollers respectively. These figures reveal, as can readily be seen, a functional relation between C and D that is expressed by the formula:

$$C = 70{,}400\,D^2$$

Substituting this value of C in the formula for rated safe load gives:

$$R = 11{,}264\,PLD/\sqrt[3]{S}$$

I trust that this simplified formula will be of value to readers of *Product Engineering* who frequently find it necessary to calculate the safe load capacity of needle bearings.

Can You Work This One?

H. E. SMITH
Newark, N. J.

This Month's Problem—

Dollars and Cents

A man cashes a check and, by mistake, is given as many cents as the check calls for dollars and as many dollars as the check calls for cents. He later spends $1.93 of this money and then finds that he has two times as much left as his check originally called for. What was the amount of the check?

Solution to Last Month's Problem—

Larger Incomes

Brown's annual income will always be $50 higher than that of Jones. For example, during the first year, Brown received $1,050, whereas Jones received $1,000; and during the second year Brown received $1,250, whereas Jones received $1,200.

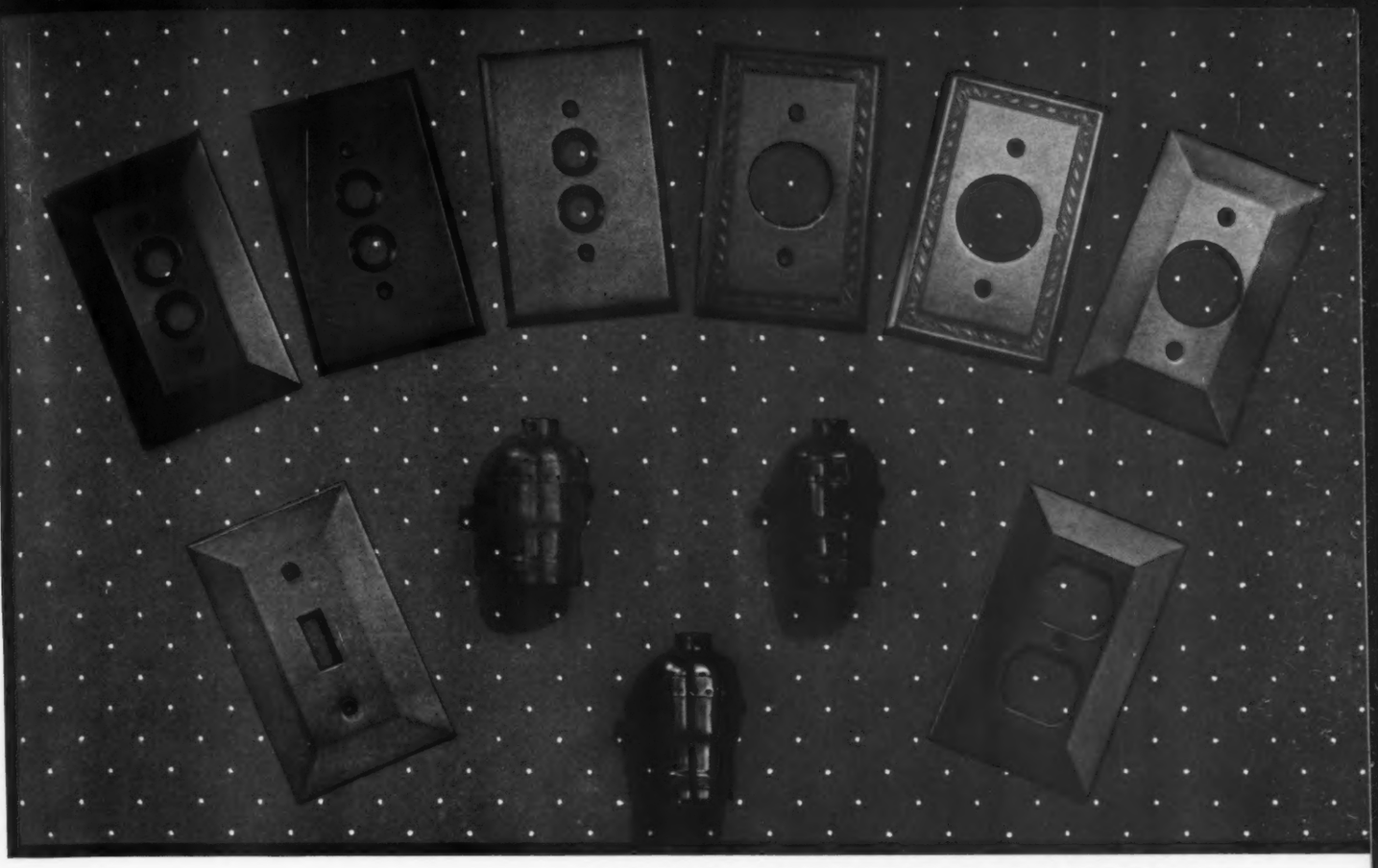


Fig. 1—This group of switch plates and sockets gives some idea of the range of finishes in Electrocolor. Note the brilliant highlights on the sockets, an indication of the high metallic lustre obtained

COLOR PLATING

A New Electrolytic Process

A new process whereby metallic surfaces are colored without the use of dyes or pigments and which gives an inherent brilliance and metallic lustre or a soft egg-shell finish, as may be desired. Innumerable color combinations can be obtained

EVEN the greatest skill of the art of engraving and color printing can give only a general idea of the effects of depth, brilliance, lustre and delicate gradations of color obtained by this new process, whereby colors are produced electrolytically. Almost any color of the rainbow can be obtained and in any degree of brilliance from an eggshell to a mirrorlike finish, giving beautiful effects that are hard to imagine and impossible to describe. To fully appreciate the effects attainable one must see articles that have been finished by this process. The electric lamp sockets in the above illustration give an idea of the brilliant highlights that can be obtained.

This process is the property of Kansas City Testing Laboratory, the owner of the patents and patent applications, and was developed for commercial use by the United Chromium, Inc., as exclusive licensee. The trademark "Electrocolor" to designate the color finishes produced by this process has been registered at the U. S. Patent Office.

All the colors that are attainable by this process, and the range includes almost every color of the spectrum, are produced in a plating bath, the composition of which is not changed or varied in any manner in order to effect any change in color, the color produced being primarily a function of the length of time that the article remains in the plating bath. The bath is preferably a water solution containing complex copper ions, in which the article to be finished is immersed and serves as the cathode. Pure metallic copper is used as the anode and the plating deposit is cuprous oxide. The bath is operated at low voltage, the usual desirable constant voltage being approximately 0.4 volts, with a current density of approximately 0.5 amp. per sq. ft., which is also surprisingly low. The cost of the bath amounts to about 65 cents per gal., and it is stable and can be operated continuously.

All colors available are produced in one bath, the composition of which is uniform and need not be modified in order to effect any change of color. It will be readily appreciated that this is a great advantage where a number of different colors have to be produced in commercial operation, as any change in color does not necessitate any interruption of the production cycle. It makes possible economical handling of small production orders which have to be finished in special shades, and eliminates any waste of specially colored lacquers, dyes or pigments, which can hardly be avoided in other methods of coloring.

The color obtained is the result of the

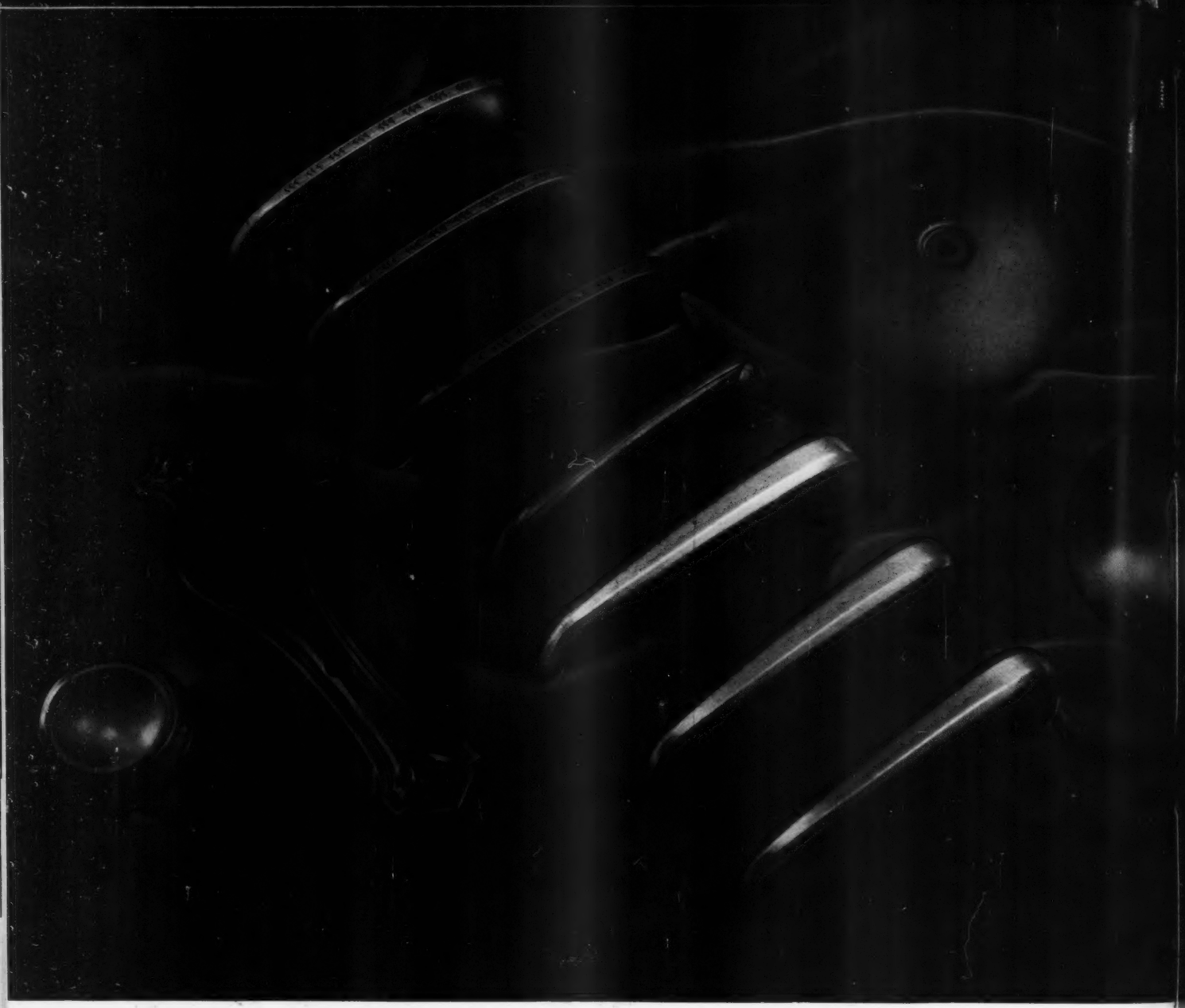


Fig. 2—Automobile and building hardware finishes in Electrocolor, the colors ranging from brilliant gold to dark dull brown

reflection and refraction of light passing through the semi-transparent, electrodeposited coating. As the thickness of the coating increases the color changes successively from violet to blue, green, yellow and red in cycles. This cycle of color changes is repeated as the plating builds up, but in each succeeding cycle the colors become darker. Finally, if the plating is continued long enough, the so-called "pigmentary-colors" are produced and these are of a deeper and darker shade.

The length of plating time may range from 1 min. to 30 min. or more. The rate of change of color during plating is relatively slow so that it is easy to reproduce the same color on the same kind of surface merely by timing the plating operation.

Another factor that determines the final shade, color and brilliance is the character of the surface before plating. A highly polished surface gives a mirror-like finish; a scratch brushed surface gives a soft egg-shell finish. Further, different colors can be obtained by preliminary plated deposits of other metals such as pure copper or nickel. In every instance the reflective brilliance of the final finish corresponds to the polish of the base surface before plating.

Preparations for Plating

A piece removed from the plating bath may again be inserted and the plating operation continued without interruption and with no harmful effect. A piece left in the bath beyond its scheduled time may easily be stripped and again colored. This operation does not involve any difficulty whatsoever, nor is there any danger of etching the surface in removing the deposit once applied. The bath operation cycles in any given color, say a green, are recurrently obtained at different time intervals, there being a slight difference in the color at each cycle. A full range of colors may be obtained in the first cycle as well as in later cycles, although, as already stated, there will be a slight difference of shades. Finally, the so-called "pigmentary colors" may be produced by longer treatment, though here the choice of color is more limited with a tendency towards the "reddish browns."

Summarizing, the commercial use of Electrocolor involves no unusual step in its application. The preparation of the articles to be plated involves the usual steps common to other electrolytic plating processes for the cleaning and preparation of the original base surface. Preparing an article for colorplating involves a choice of the most suitable base metal solely from the standpoint of the functional characteristics thereof, the polishing of that metal to the desired degree, and the cleaning of that surface.

This first step may be followed by an

pointing out that not only can the choice of color be varied to an almost unlimited degree by the actual plating operation, but it may also be further controlled and regulated by the choice of preliminary deposits of other metals, such as copper or nickel. Furthermore, it may be varied by a proper choice of polishing operations on the base; an article may be either highly polished or produced with a dull finish, and the final appearance of the article varied from the brilliance of high metallic lustre to the softness of a subdued pastel shade.

Colors Easily Duplicated

Any shade and color once produced can be duplicated and matched with absolute accuracy and consistency merely by specifying the base metal, its surface finish, preliminary platings, and the length of time in the plating bath. Thus, the duplication of any color once produced does not involve keeping in stock a range of color dyes or pigments, or the renewed purchase of such products. Nor does it require analytical color matching. It is solely a question of the initial surface and the length of time in the plating bath. The accuracy with which this time must be measured is well within the range of careful commercial production.

Control of the composition of the plating bath, of the temperature and of the operating voltage or the current density is required. In common with other types of plating equipment provisions for taking care of these essentials can readily be made.

The ease with which colors can be duplicated and varied gives the process many unique advantages. Any given shade and color can be designated by a code or key number. Instead of specifying a certain color, the number specifies the surface finish of the bare metal, preliminary platings if any, and the length of time the article is to remain in the plating bath. Thus, the exact shade will be reproduced without color charts or color samples. Nor is it necessary to experiment with color pigments, color matching or a color analyzer to produce the color desired. And in addition to this it is possible to change successive pieces from one color to another, within the wide limits of the process, at practically no cost. Thus, flashlamp cases, switch plates or lamp sockets can be finished in a whole line of colors at practically the same cost as producing all of the same color. Considering the great emphasis that is being placed on appearance and the merchandizing advantages of being able to offer a product in a wide range of shades and colors, these features have a distinct value not possessed by other types of finishes.

From the technical operating standpoint, one of the most noteworthy characteristics of the bath is its throwing power, which makes it possible to color recessed articles without any auxiliary anodes, and without any variation in the shade of color. It is possible to treat almost all of the usual base metals. Some of these, such as aluminum, may require preliminary coatings of other metals, but in general the process leaves the user free to choose whatever base metal will best satisfy his needs from the standpoint of economy, ease of finish-

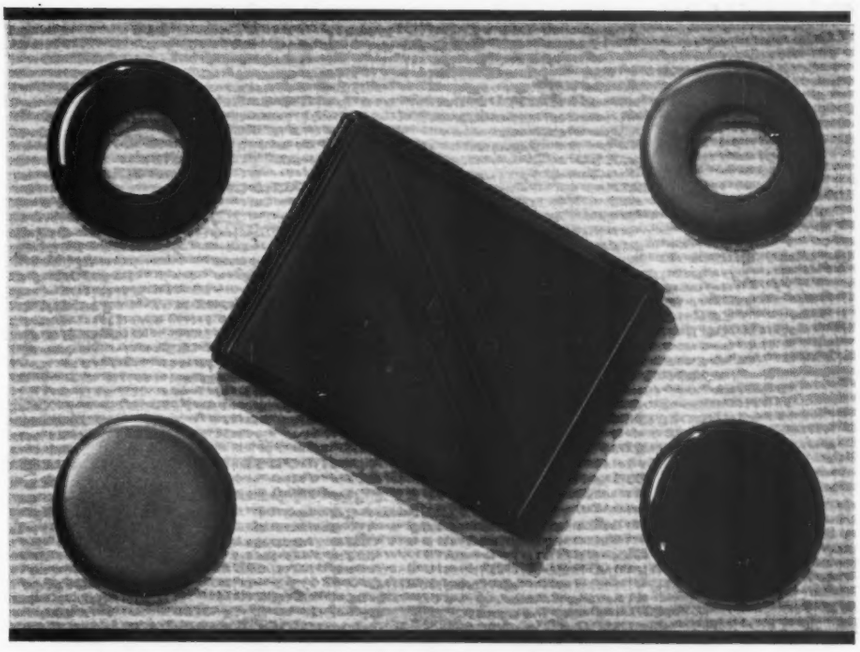


Fig. 3—Watch cases, and cigarette cases—dull or brilliant lustre—finished in Electrocolor

intermediate step of further electrolytic treatment for the purpose of improving the wear and corrosion resistance of the piece, or of applying another base metal in order to obtain a particularly desired shade. Here again the operation of the process corresponds with the general procedure in common use in electroplating plants. For example, a steel piece may be copper and nickel plated either for the purpose of applying the color over a deposit of nickel, or, as is now done in chromium plating, to secure a durable finish more resistant to corrosion, giving longer life. As in the case of chromium plating for decorative purposes, the color deposit is a final electrolytic step in obtaining the desired decorative appearance, and the preparation of the piece up to this point proceeds along lines very similar to an article to be chromium plated.

The great range of other possibilities that are available may be indicated by

ing and strength. The range of colors is very wide and closely approximates that of the spectrum.

Variations and additional effects that can be produced by special treatment of the articles to be colored are almost unlimited. For instance, two-tone effects can be produced by the simple expedient of stopping off part of the area to be colored for a portion of the time. It is also possible to obtain combinations of chromium plating and color by simply stopping off certain portions of the article prior to chromium plating and then coloring those portions directly, leaving the chromium plated area unaffected. This can easily be done by making the chromium deposit passive, so that no color is deposited thereon.

As an example of the almost endless variety of color combinations that are possible, the part in the lower center of Fig. 4 was masked and the decorations chromium plated. The chromium plated portions were then made passive and the remaining surfaces Electrocolored. Nameplates are made in this manner, giving attention compelling contrasts of color and reflectivity.

Similarly, portions could be copper plated or nickel plated and the Electrocolor put over the whole surface. Or portions could be masked, the article color plated for a certain length of time and then the mask stripped off and the color plating continued. It can readily be seen that the possible variations are almost endless.

Subsequent to the coloring, a clear lacquer is applied over the whole surface. This is for the purpose of giving increased wear resistance and protection to the color finish. The characteristics of the lacquer used may be varied in order to obtain the best results for the purpose for which the article is to be used. It is possible to obtain for this purpose tough wear resistant lacquers, moisture proof lacquers and lacquers that are resistant to alcohol and other solvents and which do not discolor with time. It should be emphasized that the color plating is absolutely light fast and free from fading and as long as the plating is protected against moisture absorption and corrosion, no amount of exposure to sunlight will alter the shade of the electrolytic coloring.

For the company with an established plating plant, the addition of this new process means nothing more than the addition of the new to the old, and the process will fit in with its established operations with great ease. For the company that has not heretofore carried on plating operations of its own, the process comes to it in a state of completed technical development, and with the technical assistance rendered by the licensor, such a company need only install the necessary equipment, the cost of which is comparatively low, and provide the services of an intelligent and careful operator, whose training will present no serious problems. For companies whose requirements are not sufficiently great to justify the installation of their own equipment, Electrocolor will be made available through job platers.

Possible applications for this process seem to be unlimited. Its primary purpose, of course, is to produce decorative effects, and it has become available at a time when manufacturers of all types of articles are seeking to conform with the modern trend toward color. Such articles as toilet sets, vanity cases, novelties in general, costume jewelry, clocks, interior hardware, flashlight cases, picture frames, articles of household utility, moldings and other areas to be colored for decoration, are only a few of the more obvious applications that have already appealed to manufacturers. The availability of an efficient and inexpensive method of coloring also has many technical applications, where it is desired to use a color as a means of identification of metal, wires, pipes, tubings, etc.; also, for the production of identification disks and kindred applications, where color is desired.

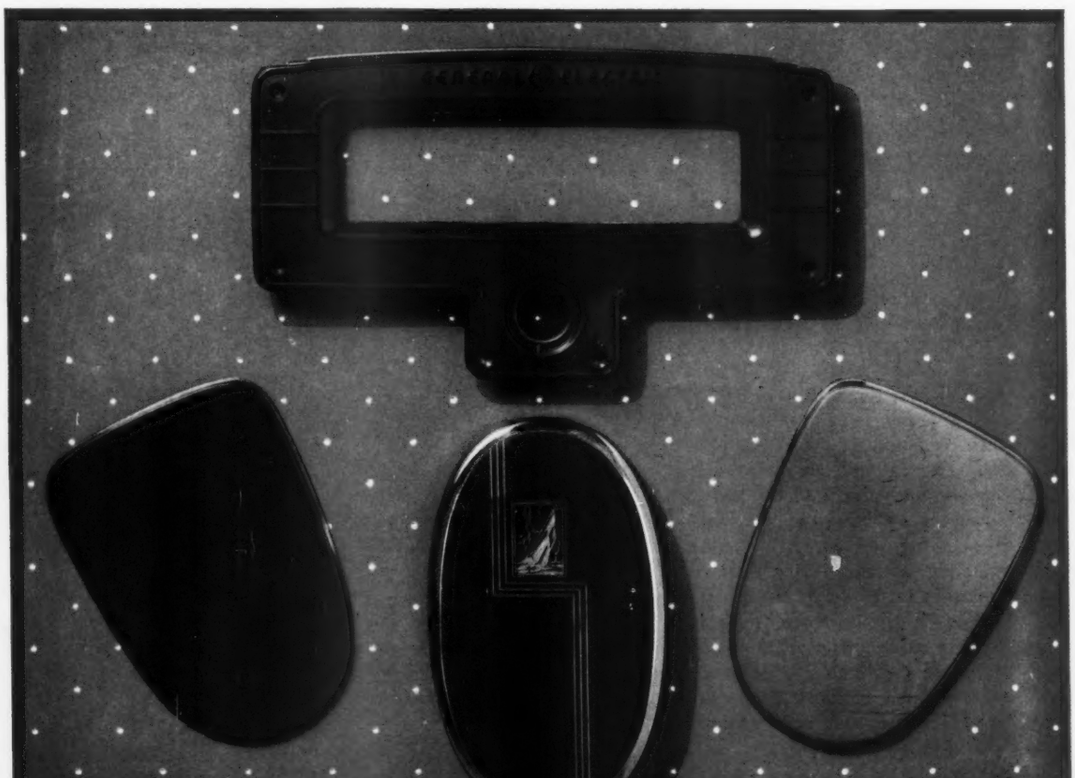


Fig. 4—Plain colors or decorative effects are equally easy to obtain. Lower center is an example of Electrocolor combined with chromium plating

News

Progress in Locomotive Design

AT THE SUMMER meeting of the A.S.M.E., recently held in Detroit a paper was presented on "Modern Locomotive and Axle Testing Equipment," prepared jointly by T. V. Buckwalter, O. J. Horger and W. C. Sanders of the Timken Roller Bearing Company dealing with refinements to improve the high speed operation of steam locomotives from which paper the following is abstracted.

The general objectives are: reduced dynamic augment on the rails because of unbalanced rotating and reciprocating parts, improved movement of the locomotive over the track by reducing nosing and fore-and-aft vibrations, increased availability, reduced operating maintenance cost, greater acceleration, increased speeds and increased tractive effort.

Cooperation of the various railroads with the Timken Company has resulted in modifications of locomotive design which incorporate the applications of: light-weight reciprocating parts including the piston, piston rod and crosshead assembly; light weight main and side rods; roller bearing crosshead pins, main pins and side pins; and roller bearing equipped driver, trailer, engine and tender truck axles.

Obviously higher speeds require either a reduction in the weight of the reciprocating parts and the rotating parts or stronger locomotive and track structure. The more economical procedure of reducing weight was followed with the result that a reduction of 1,072 lb. per side and up to 52 per cent of the conventional designs has been made. Dynamic augment curves show in general that it is possible by the reduction of weight to increase the diameter speed of steam locomotives by about 35 mi. per hr. without change in the dynamic augment. The reduced weight results in greatly decreased horizontal forces acting to cause vibrations and to stress the locomotive frame, axle and other members.

In the new design eye ends of the rods are deep narrow-width I-sections. The column stresses resulting from eccentric loading are small because the narrow width of the rod ends and their action on the outer race of the bearing has very little eccentricity. Knuckle pin joints in side rods, oil and grease holes through the rod eye, which introduce high local stresses and cause many rod failures, have been eliminated.

Crank pins have thin-walled tapered tubular sections, while the crank pin bearings are of the usual tapered roller design fitted directly to the crank pins. The crosshead pin serves as the inner race of the bearing.

In this light weight design a piston rod having a ¾ in. wall section is keyed by three integral annular grooves on the end of the piston rod to a crosshead consisting of two thick die forged side plates. The series of annular rings are machined to close tolerances, using gages, and then the piston rod is lapped into the crosshead body.

A forged and rolled shape of comparatively thin section, permitting deflection several times as great as usual, is used for the conical piston which has only two piston rings.

Chrome-Nickel-Moly Used

Rods, pistons and the principal members constituting the revolving and reciprocating parts required a material possessing high yield strength, high endurance limit, good ductility and impact strength. To meet these requirements and to obtain a favorable strength-weight ratio a Cr-Ni-Mo alloy steel was used for these parts. Good forging, heat treating and machining characteristics are also required.

The driving rods, piston, and crosshead are all die forged; the piston rod is made from cold drawn steel tubing, and the crank pins are hammer forgings. To obtain beneficial effects of grain flow it was necessary to develop proper die shape and forging technique. Longitudinal sections of the eye were made to determine the proper grain flow so that in the subsequent machining operations cutting would be parallel and not transverse to the flow lines.

The eye and slightly over half of the column section of the rod is die forged in three forming, blocking and finishing operations. The opposite end of the rod is forged in a similar manner and a center die is used to straighten the column section with the ends and to control the length.

Design of the column sections used in the main and side rods is based on compression tests of full-size tapered columns. The columns tested were machined from standard structural steel I-beam sections to dimensions comparable with those of full-size main and side rods used in service. The purpose of static tests on full-size sections was to investigate the stress distribution in various designs of eye sections and to determine the increased magnitude of these stresses because of the variation of clearance from minimum to maximum values anticipated in service.

Diameter Tolerances for Galvanized Bolts

BOLTS AND NUTS after being galvanized will, upon assembly, be found to fit either too tightly or too loosely unless the proper allowances for the thickness of the galvanized coatings have been made in establishing the tolerances. To solve this problem, Henry W. Bearce, co-chief of the Weights and Measures Division of the Bureau of Standards made an analysis of the pitch diameter tolerances established by the National Screw Thread Commission and how they were affected by galvanizing. From his studies he concludes that if nuts are tapped to pitch diameter limits between Class 3 max and Class 1 max, and the bolts are threaded to pitch diameter limits between Class 2 min. and Class 1 min., before galvanizing, the bolts and nuts will assemble after galvanizing without being either too tight or too loose. He suggests the use of Class 3 no-go plug gages and Class 2 no-go ring gages as the go gages to be used in the preliminary inspection prior to galvanizing. This will make it unnecessary to purchase special size go gages.

A.S.T.M. Meeting Breaks All Records

THOSE WHO attended the A.S.T.M. annual meeting, New York City, June 28–July 2, found it difficult to divide their time between the 19 formal sessions devoted to the presentation of technical papers and reports, the 200 sessions of the various committees, and the exhibit of testing machinery and laboratory equipment displayed by more than 40 companies. The attendance, more than 1,500 registered, exceeded all previous meetings.

Of special interest to designing engi-

neers were the sessions on the fatigue of metals and the effects of high temperatures. The report of the joint research committee of the A.S.M.E. and the A.S.T.M., on the effect of temperature on the properties of metal, under the chairmanship of H. J. French, summarized the various new sponsored research projects which included test studies of tubes at elevated temperature, long-time creep tests on carbon steel, investigations of properties of metals at low temperatures, torsion creep tests for comparison with tension creep tests, and various other phases of the creep problem. This committee also included a report on two investigations, "Long-Time Creep Tests of 18 Per Cent Chromium, 8 Per Cent Nickel Steel, and 0.35 Per Cent Carbon Steel," which was a sponsored research project carried out at Battelle Memorial Institute, and report on "Discrepancies in the Load-Carrying Ability of Carbon Steel at 850 Deg. F."

Papers on Creep and Fatigue

At this same session Joseph Marin of Rutgers University delivered a paper on "A Comparison of the Methods Used for Interpreting Creep Test Data," which paper discussed the various methods of comparison for the purpose of obtaining working stress values. Prof. P. G. McVetty of Westinghouse Electric & Mfg. Co., described new creep-testing equipment for creep tests at elevated temperatures. John Boyd, of the Engineering Foundation, described a method of stimulating relaxation conditions in testing by means of an automatically controlled interrupted creep test. A fatigue machine for testing metals at elevated temperature was described by F. M. Howell and E. S. Howarth of the Aluminum Co. of America, and a paper by T. T. Oberg and J. B. Johnson, of the U. S. Army Air Corps, described a ball-bearing rotating beam machine operating at 10,600 cycles and discussed the fatigue properties of plain and notched specimens tested on this machine.

Committee A-1, on Steel, presented seven proposed new tentative specifications covering various alloy plates and tubes and proposed adoption as standard of several tentative specifications.

A paper by L. J. Larson, of the A. O. Smith Corp., on "Weld Metal as an Engineering Material," discussed the need for a knowledge of the properties of weld metal and the standard special tests used for determining the desired properties.

"A Fundamental Study of the Design of Impact Test Specimens" was presented by H. C. Mann of the Watertown Arsenal, in a paper wherein he discussed the effect of length and form of notch on the energy values obtained from the tension-impact test.

In the session on corrosion, Committee A-5 made its report on the corrosion of iron and steel. D. K. Crampton and N. W. Mitchell, of the Chase Brass & Copper Co., delivered a paper, "Corrosion Testing Methods for Copper Alloys," wherein the types of corrosion are discussed from the standpoint of cause and results. A "Corrosion Symposium Digest" was presented by L. W. Hopkins, of the American Chain Co.

In the session on "Methods of Testing," Mr. R. K. Bernhard, consulting engineer for the Baldwin-Southwark Corp., described "Dynamic Tests by Means of Induced Vibration," a method of investigation that has been used since 1928 for all types of tests ranging from small laboratory specimens to the heaviest materials. The paper was illustrated by motion pictures.

In addition to the various committee reports presented at the session on "Non-Ferrous Metals," C. H. Greenall and G. R. Gohn, of the Bell Laboratories, presented a paper on "Fatigue Studies of Non-Ferrous Sheet Metals." This paper presented data on the fatigue characteristics of 24 non-ferrous sheet metals and discussed the effects of grain size, heat treatment, surface finishes and plated finishes on the fatigue properties of these metals.

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MEETINGS

NATIONAL METAL CONGRESS—*Held in conjunction with the National Metal Show and participated in by five international societies, the American Society for Metals, the Iron & Steel Division, and the Institute of Metals Division of the American Institute of Mining & Metallurgical Engineers, the American Welding Society, the American Society of Mechanical Engineers, and the Wire Association. W. S. Eisenman, managing director, 7016 Euclid Ave., Cleveland, Ohio.*

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—*Fall meeting, Erie, Pa., October 4–6. Ernest Hartford, assistant secretary, 29 West 39th St., New York City.*

EXPOSITIONS

CHICAGO EXPOSITION OF POWER AND MECHANICAL ENGINEERING — *International Amphitheatre, Chicago, Ill., October 4–9. Charles F. Roth, manager, Grand Central Palace, New York City.*

SIXTEENTH EXPOSITION OF CHEMICAL INDUSTRIES — *Grand Central Palace, New York, December 6–11. Charles F. Roth, manager, Grand Central Palace, New York, N. Y.*

NATIONAL METAL SHOW—*Atlantic City Auditorium, Atlantic City, N. J., October 18–22. W. S. Eisenman, director, 7016 Euclid Ave., Cleveland, Ohio.*

NATIONAL AUTOMOBILE SHOW—*Grand Central Palace, New York City, October 27-November 3. Alfred Reeves, manager, 366 Madison Ave., New York, N. Y.*

Cooperation Saves $20,000 Per Year

SPEAKING at a recent meeting under the auspices of the American Foundrymen's Association and the New England Foundrymen's Association at the Massachusetts Institute of Technology, Dean Smalley, engineer, small motor department, General Electric Company, described how close consultation between designers and foundrymen saved his firm more than $20,000 a year in the cost of producing only two parts.

"Before we make any detailed drawings" he explained, "we spread on a table a layout of what we think we want. Men from the foundry, pattern shop and various designers concerned then discuss the layout, and the pattern makers and foundry men present their objections. In practically every case the objections are not serious to the design and when we get through we usually have a better design simply because we have drawn on the experiences of the pattern maker and foundry man."

Mr. Smalley described a number of instances wherein such close cooperation resulted in a better product at less cost. In one case, raising the wall of a casting eliminated a number of pockets about two inches deep which would have been cast in the cope. This slight change reduced the price of the casting from $3.10 to $1.90 and the resulting casting was much better to machine. In another case radial internal ribs met at a hub in the center with the result that the ribs came extremely close together near the central hub. By cutting back alternate ribs,

Do You Know That—

In 1887 flat-rolled steel accounted for but 11 per cent of the total output of rolled iron and steel, whereas in 1936 flat-rolled steel constituted approximately 50 per cent of the total output? (55)

Although the tensile strength of glass in the form of rods is only about 20,000 lb. per sq. in., the strength of commercially produced glass fibres varying from 0.0002 in. to 0.02 in. in diameter, averages 250,000 lb. per sq. in.? In several experimental tests, strength as high as 3,500,000 lb. per sq. in. has been reached. (56)

Stainless steel moldings have been made available for decorative trim purposes, and are being used liberally on 1937 automobiles, domestic furnace casings, and air-conditioning cabinets? (57)

almost 80 cents per casting was saved.

By changing a design so that a core could be made in one piece instead of being made in four pieces and pasted together, the unit cost of the casting was reduced from 75 cents to 56 cents. By eliminating projections on another casting it made it possible to produce the castings on the squeezing machine with the result that the cost was reduced from 78 cents to 54 cents.

In summarizing the results obtained by this close cooperation between designers and the various individuals concerned with producing the patterns and castings, Dean Smalley stated that the cost reductions that have been procured range from 22 per cent to 45 per cent, a saving in one year's production of only two designs of castings amounting to between $20,000 and $25,000.

New Research Products by Mellon Institute

EXPERIMENTAL work extending over a period of years at the Mellon Institute of Industrial Research has resulted in the production of a porous, non-warping ceramic body that is impregnated with bituminous substances and then heated under special conditions to form coke in the pores. Unusually high resistance to thermal shock is imparted to the material because artificial cordierite, a mineral that has a very low thermal expansion, is used in making up the ceramic body. Thus there was produced a material that can be polished to velvety smoothness, possessing sufficient hardness to resist scratching and abrasion, ample structural and impact strength, denseness that prevents absorption of liquids, resistance to solvent action and chemical attack, and the ability to withstand perfectly the effect of rapid heating and cooling. In other words, "Kemite," as it has been called, has none of the disadvantages of the commonly-used table top materials.

The weight of Kemite is 117 lb. per cu.ft., its water absorption percentage ranges between 0.75 per cent and 1 per cent, its transverse strength is 3,000 lb. per sq. in. and its crushing strength 11,300 lb. per sq. in.

Although developed primarily as a laboratory table top material, it is evident from a consideration of its inherent properties that the material has great promise for many uses in other fields.

Case Histories in Patent Law

H. A. TOULMIN, JR.

[Editor's Note: *We wish to emphasize that in consenting to furnish this column wherein general explanations of the law in specific patent cases are set forth, Col. H. A. Toulmin, Jr., wants it clearly understood "that each actual case should be submitted to your own patent attorney who is the only one familiar enough to advise you accurately." The purpose of these explanations is to give a better general understanding of questions of patent law.*]

QUESTION: Why, and in what respects, is careful wording of a patent application important?

ANSWER: Many a potentially valuable invention has failed of patent protection because the application for a patent was carelessly or inexpertly drawn. Certain mistakes in making disclosures and in defining the scope of an invention are so frequent that special statutes have been passed to protect the inventor.

Engineers seem to be peculiarly prone to err. They are, perhaps, so steeped in their profession that they have trouble understanding just what is and what is not invention. They are inclined to stress those things which are important to them, but which are unimportant from the standpoint of invention. Often the really important features of the invention are passed over as being nothing more than evidence of their technical ability.

Trouble may arise from claiming too little or too much in the application. Usually the cause is misunderstanding between the inventor and his attorney. Any capable patent attorney can be trusted to draw up a proper application, provided he has been given accurate information about the invention by the inventor. But so common are such misunderstandings between lawyer and inventor that it has been necessary to provide for them by means of reissue patents.

TYPICAL CASES: In an application it pays to make no reference to any previous patent which the inventor may have but to let it speak for itself if the occasion ever arises. For instance, the holder of a patent on an important trailer hitch brought an infringement suit. The defendant was able to show that he had not infringed because the patentee had referred in his application to a previous patent of his own and in doing so had credited it with a much greater disclosure than it had made. This prevented him from claiming that his later patent was broad enough to cover what he supposed was an infringement.

This inventor had probably made the common mistake of pointing out to his lawyer various things in his invention which he assumed were old but which were not. That made the later application cover merely an improvement on an old patent. The "old" things should have been carefully and specifically covered by the application.

If an inventor's application contains a complete, clear description of his invention, he is safe provided, of course, that his invention is patentable.

A misunderstanding between client and lawyer resulted recently in an inventor's getting a patent which did not cover the invention his application disclosed. The invention involved an electric switch for use with water tanks. The application should have, but did not, cover a fitting to close an opening in a tank which served as a means of mounting the float device, the valve, and the complete operating mechanism of the tank.

A reissue patent was refused because the inventor's attempt to get his claim was unlawful in that he was trying to secure a patent for a different invention from that which he had disclosed in his original application.

The safe course is to give the lawyer a complete description of the invention, and see that he has a full knowledge of the prior art, then let him select the features which are invention and patent them.

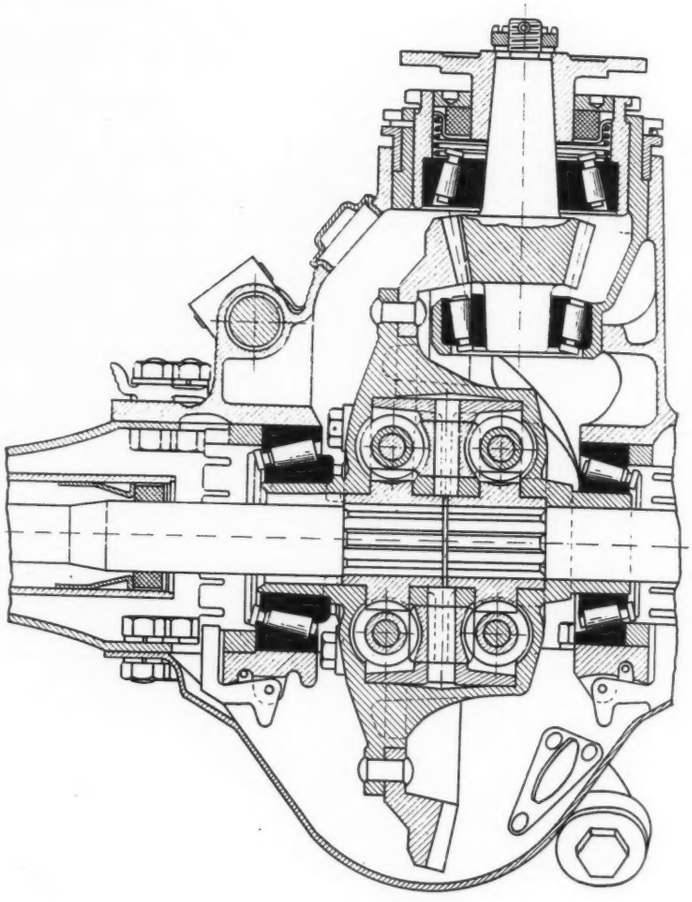
Should the lawyer claim more than the invention warrants, usually because the inventor has insisted on asking for too much, no great harm is done, for the inventor can then disclaim those claims to which he is not entitled. The supreme court has recently laid down the signpost rules for such disclaimers.

However, when an inventor is correcting the error of having originally claimed too much, he must be careful not to rewrite the claim and include new elements. In some recent motion-picture patents cases, for example, the inventor disclaimed a claim involving the flexing of the film record but made the mistake of adding a flywheel device. This was held to be improper.

The best way to avoid trouble is to have complete understanding between inventor and client and to have the claims so clearly set forth that there can be no question as to the boundaries of the patent.

AUTOMOTIVE DIFFERENTIAL

Fig. 1—A design used in heavy vehicles in which the bevel driving pinion shaft is straddle mounted on taper roller bearings. A ring bevel gear is riveted to the flange of the differential carrier. The differential is of the positive type, the gears of which are of a spiral spur form with high frictional losses, so that the road wheel offering the greater traction will take the drive. This is just the reverse of the conventional free-running differential. Some vehicles have been built experimentally without differentials, and some with differentials which could be locked positively when adverse tractive conditions were met.



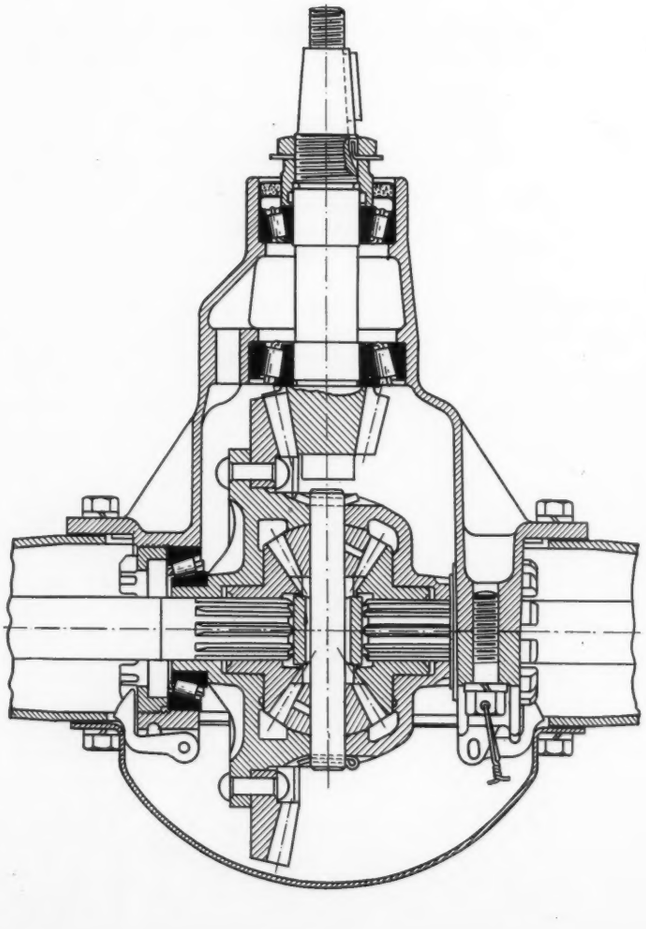


Fig. 2—An early design of a differential assembly using all straight-tooth bevel gears. Both radial and thrust loads on the driving pinion shaft are distributed over taper roller bearings which are spaced some distance apart to maintain shaft alignment. A ring bevel gear is riveted to a flange of the differential carrier which is fitted with bevel gears. Both hubs of the carrier rotate in taper roller bearings and are mounted so that axial adjustment of the ring gear can be made by means of externally threaded nuts to obtain accurate meshing with the driving pinion. In contemporary designs provision is also made for axial adjustment of the driving pinion.

GEAR MECHANISMS—I

Examples of rear axle drives that have been used on passenger cars and trucks to distribute torque equally between the driving wheels and also to permit one wheel to turn faster than the other on curves

HERBERT CHASE

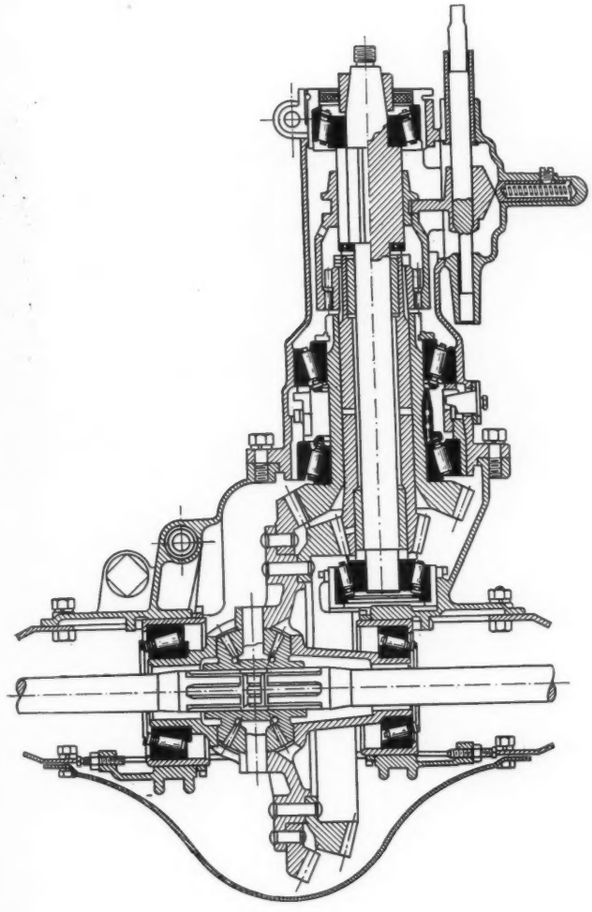


Fig. 3—Two-speed drive combined with differential, consisting of a selective driving clutch, two driving sleeves each integral with a bevel pinion, two ring bevel gears riveted to a flange of a differential carrier, and differential gears. At the forward end of the large pinion sleeve are cut splines, at the forward end of the small pinion sleeve a splined unit is keyed on, these form halves of a positive clutch arranged so as to mesh with a sliding selective driving member which is splined to the driving axle. With the larger pinion engaged the engine speed is lower for a given road speed than with the smaller pinion in engagement, thereby increasing the power and the fuel economy but reducing the ability to accelerate.

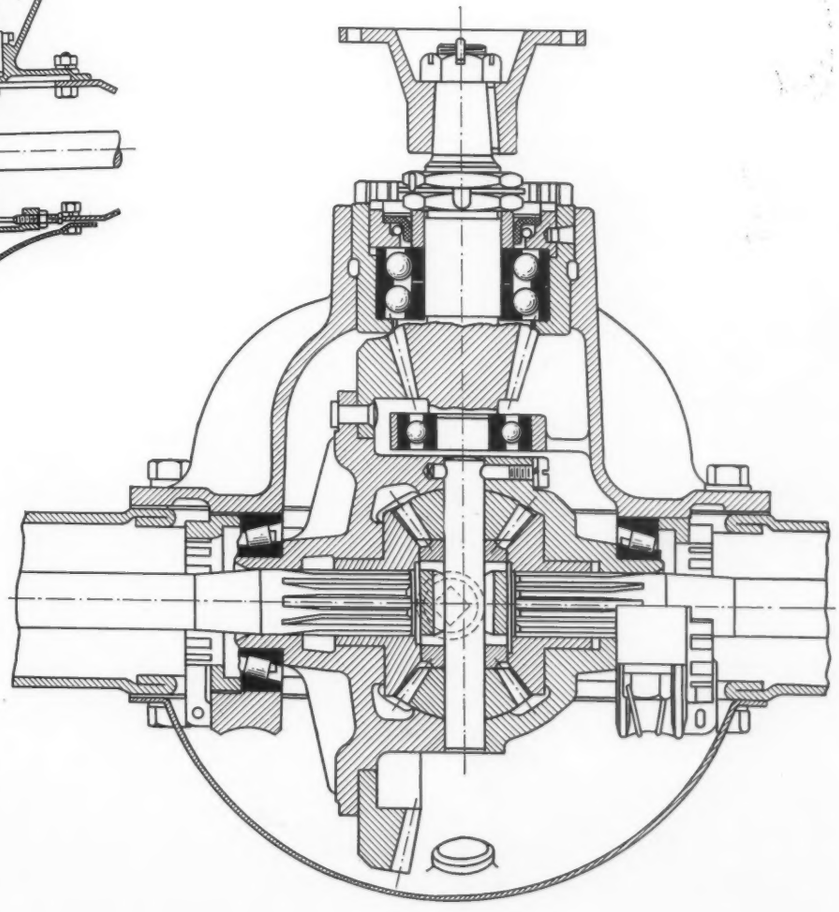


Fig. 4—A typical example of a differential using spiral bevel gears which has displaced the straight bevel styles primarily because of its quiet operation. As compared with straight bevel gear forms it employs smaller pinions and ring gears and requires a smaller housing, the tooth loading is higher but the teeth are stronger and the area of contact is greater. A rigid mounting is essential and is obtained by using an outboard bearing and a double-row ball bearing placed close to the pinion to take both thrust and radial loads. A rigid differential carrier is riveted to the ring gear. The carrier is mounted in tapered roller bearings.

New Materials and Parts

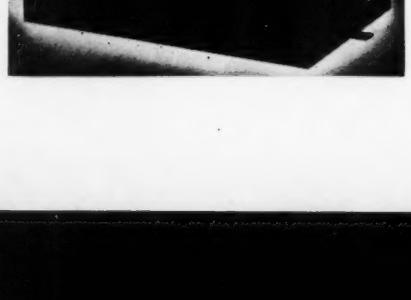
Resilient Mounted Motors

Annular-type resilient-mounted motors, 1/8 to 1 hp., repulsion-start-induction (illustrated), split-phase, capacitor and polyphase types. The motor base is made of rolled sheet steel shaped in the form of a cradle with large rings of rubber, which support the motor, vulcanized to inner and outer steel rings. This type of mounting has the advantage

in that there is less vibration, hence less noise, since the rubber mounting supports which absorb the vibrations are as close to the shaft center as possible. The motor is locked into place in cradle arms by means of latches and latch-nuts, but can easily be removed from the base by loosening the latch-nuts and removing the latches. These motors are also available with belt-tightener bases, so designed that the belt tension increases with the load. Wagner Electric Corp., 6406 Plymouth Ave., St. Louis, Mo.

Power Storage Battery

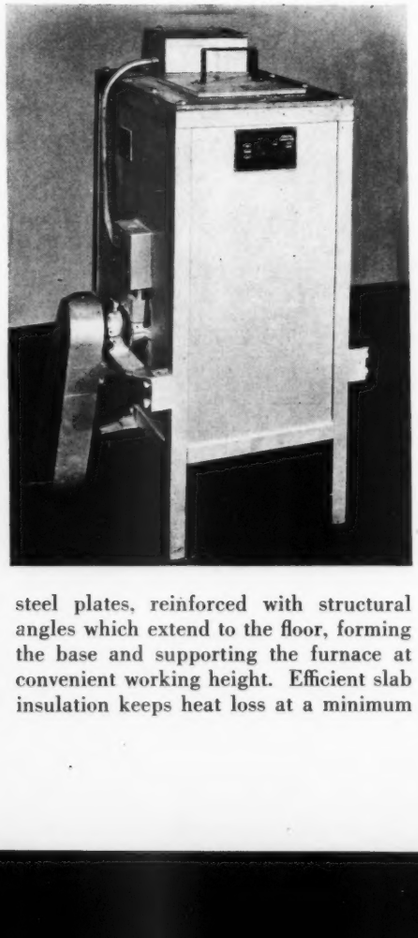
Known as the USL Durapak, for use in industrial trucks, electric locomotives, railroad car lighting and air-conditioning. The positive plate is of sectional construction to withstand expansion and



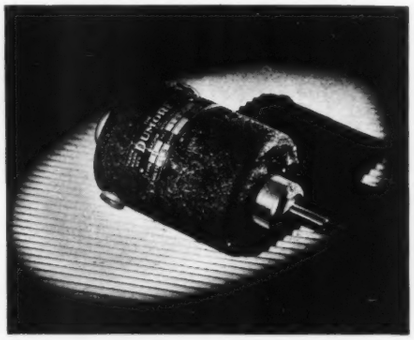
contraction stresses. A heavy, one-piece, interlocking plate grid provides greater mechanical strength and conductivity. Plates are machine-pasted for greater plate uniformity. Glass fiber retainer pads prevent loss of plate material and are held firmly against the plate surface by a special plate shielding, permanently shielding the entire plate. Other features include "Permatex" all rubber separators to balance the long service life of the positive plates and improved negative plates with tapered tops and insulated edges for extra protection against short circuits. USL Battery Corp., Niagara Falls, N. Y.

Laboratory Furnace

A small inexpensive laboratory "Cyclone" furnace, having a work chamber 8 in. in diam. by 10 in. deep and provided with a plug type cover which is easily lifted off for inserting the load. The electric heating elements are mounted in a separate chamber thereby eliminating all direct radiation to the charge. A powerful blower fan circulates the heated air through the work chamber, insuring rapid, uniform heating. Furnace is constructed of heavy



steel plates, reinforced with structural angles which extend to the floor, forming the base and supporting the furnace at convenient working height. Efficient slab insulation keeps heat loss at a minimum throughout the temperature range up to 1,250 deg. F. Serves as an accurate and inexpensive pilot furnace for checking up on production, or for predetermining the response to specified heat-treatments, as well as for tempering small tools and individual steel parts. Lindberg Engineering Co., 221 Union Park Court, Chicago, Ill.



Universal Motor

Available in several different types such as ventilated, totally-inclosed, sleeve and ball bearing and with worm gear speed reduction units. The standard totally-inclosed motor, known as Type H, is rated at 1/50 hp. at 6,500 r.p.m. for 30 min. duty. The standard open motor, known as Type HV, is rated at 1/50 hp. at 5,000 r.p.m. continuous duty, or 1/55 hp. at 4,000 r.p.m. for 30 min. duty. The Dumore Co., Racine, Wis.

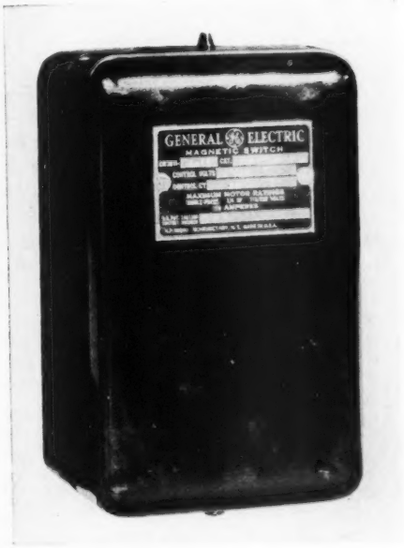
Arc Welding Electrode

Known as "Fleetweld 9". Developed especially for flat welding of deep-groove joints in mild steel for use in the manufacture of products such as tanks and pressure vessels, utilizing heavy plate construction and requiring production of highest quality butt welds at maximum economy. The electrode provides weld deposits possessing high physical properties. Proper procedure with the electrode overcomes certain conditions frequently encountered in deep-groove welding which tend to cause the formation of surface holes in the metal. The electrode has operating characteristics which assure uniformly economical performance. Properties of the metal as welded are: tensile strength 66,000 to 74,000 lb. per sq. in., yield

point 50,000 to 60,000 lb. per sq. in., ductility, elongation in 2 in., 20 to 30 per cent, varying with the composition of the plate, the heat of welding, capacity of the plate and the size of the electrode used. Impact resistance ranges from 30 to 60 ft.lb. (Izod) and endurance limit 29,000 to 34,000 lb. per sq.in. The electrode is made in three sizes, 3/16 in., ¼ in. and 5/16 in. and may be used with either alternating or direct current. The Lincoln Electric Co., Cleveland, Ohio.

Small A.C. Contactor

A new Size 00 a.c. multipole magnetic contactor, Type CR2810, for controlling small single-phase and polyphase motors, or for use as a flexible relaying device for comprehensive control systems such as used on machine tools. Outstanding



among the advantages offered by the new contactor are its compactness and the ease with which it can be installed. Can also be furnished as a magnetic switch (CR2811), mounted in either one of two sizes of sheet-metal cases which are suitable for general-purpose applications where atmospheric conditions are normal. They are provided with conveniently located knockouts. The device, used either as a contactor or a magnetic switch, has a maximum rating of 10 amp. at 600 volts. The contactor is available with a minimum of two poles and a maximum of eight poles and can be furnished in any combination of normally-open and normally-closed poles. Contacts of one form can be easily changed to opposite form by a simple change of parts. This flexibility affords a maximum utility of contactors with a small stock of parts. A standard pole is used as an interlock. All parts are readily accessible. One screw holds the coil and magnet assembly in place while the movable contacts may be removed by taking out one screw per contact. General Electric Co., Schenectady, N. Y.

Mercury Vapor Lamp Transformer

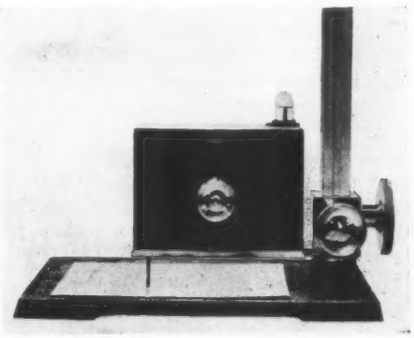
New transformer for high intensity mercury vapor lamps. Extremely thin laminations of high silicon steel are used in the transformer core, which in addition to the oversize wire for all coils insures the cool operation of the functioning units. Coils are precision wound and are of the armored insulation type, double impregnated. All connections to line or lamp are made at the terminal panels, no joints or taping being required. Connections may be made from either or both ends of transformer for mercury vapor lamp or mazda or for combination use of both types of lamps. Removable mounting legs makes it suitable for wall, ceiling or pendant mounting. A thread coupling is an integral part of the endplates and is ready for pendant mounting simply by removing endplate cover. Acme Electric & Mfg. Co., Cleveland, Ohio.

"Disc-Brake" Motor

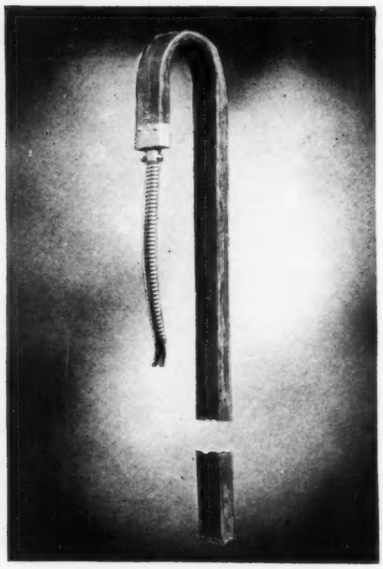
Combined functions of a motor and those of a powerful brake are claimed for this "disc-brake" motor having built-in brakes. For use on small cranes, hoists, auxiliary movements on machine tools and other equipment in which quick, automatic and accurate stopping or holding of a load is necessary. It is stated that with these disc-brake motors it is often possible to connect the drive direct and thus avoid the need for clutches. The brake consists of a compact disk-type friction device, mechanically and automatically engaged when the current is shut off and magnetically disengaged when the current is applied. Brake may be fitted to any standard Reliance motor except those of the fan-cooled type and operates equally well in any position. All mounting dimensions conform to N.E.M.A. specifications. Reliance Electric & Engineering Co., 1088 Ivanhoe Rd., Cleveland, Ohio.

Thickness Gage for Nickel-Plated Coatings

A new instrument for measuring the local thickness of an electroplated nickel coating on a non-magnetic base metal. The principle of the method involves the measurement of the force required to detach one pole of a permanent magnet from the nickel coating, and the comparison of this force with that required to detach the same magnet from a similar nickel coating of known thickness. Instrument is calibrated with nickel coatings of known thickness which have been deposited under about the same conditions as the coatings to be tested. Measurements on coatings as deposited are correct within 15 per cent and on annealed coatings within 10 per cent. The magnetic method is rapid and non-destructive and for thin coatings its accuracy is claimed to approach that of metallographic measurements. The sensitivity of the instrument can be varied by the proper selection of the spring, each division on the dial corresponding to approximately 0.00025 mm. (0.00001 in.) of nickel. Applicable to plane, convex and concave surfaces. Thin chromium coating over the nickel has no appreciable effect on the thickness measurements and is advantageous because it prevents oxidation of the nickel during



annealing. Instrument measures 5x9x9 in. high and weighs 7½ lb. American Instrument Co., Silver Springs, Md.

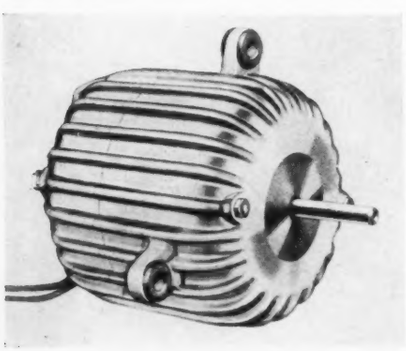


Immersion Heater for Plating Tanks

An electric immersion heater, as illustrated, for hanging over the side of a plating tank. Weighs approximately 36 lb. and is provided with flexible leads to facilitate making connections. The unit has an overall dimension of 46 in. and is rated at 3 kw., 230 volts. Casings are made of copper, steel or other alloys and lead coated when required for nickel plating, chromium plating, acid copper and acid zinc baths. The structure of the element within the unit is the same as the Trent strip and immersion units. Units of similar design bent at right angles for shallow baths can be furnished. Harold E. Trent Co., 618-640 N. 54th St., Philadelphia, Pa.

Fractional Hp. Motor

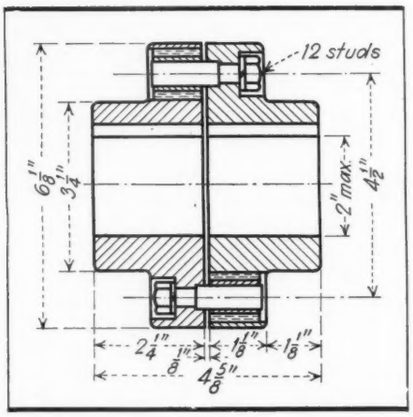
Known as Type QN-1, designed especially for hair dryers. Is of four-pole, shaded coil construction, rated at 1/30 hp. Operataes on 110–120 volts a.c.



60 cycles; full load speed 1,600 r.p.m.; no load speed 1,700 r.p.m.; full load input, 115 watts. A feature of this motor is the grease packed bearings which makes relubrication unnecessary. Also available in Type QB–1 for d.c. Signal Electric Mfg. Co., Menominee, Mich.

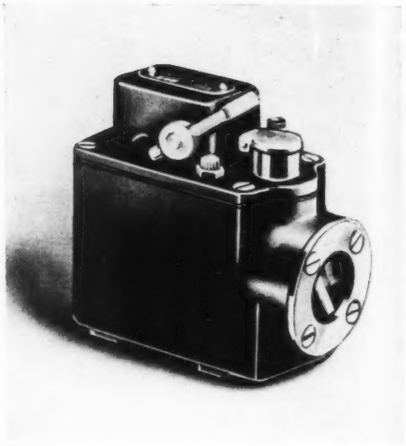
Model S-2 Flexible Coupling

Rubber-Cushioned flexible coupling for direct connected machines having a maximum bore of 2 in., an overall diameter of 6⅛ in. and weighing 20 lb. Rated at 12½ hp. at 100 r.p.m. Torque rating is 660 ft. lb. and maximum r.p.m. 7,500. Ajax Flexible Coupling Co., Westfield, N. Y.



Minimum-Capacity Lubricator

An automatic lubricator, known as Type L, having a reservoir capacity of one-quarter pint. It is designed for application on small machines where the total oil discharge required is as little as 10 drops. The pump units are supplied with or without reservoir, the latter combination being adapted particularly to machine assemblies providing a cast-in reservoir. By pressing a small lever on the side of the lubricator, the piston raises through a definite stroke, thereby drawing into the pump cylinder a definite volume of oil. On release of the lever, the metered quantity of oil is discharged, under the action of the piston return spring, into the tubing system. Thus a pressure of about 50 lb. per sq.in. is developed in the system and metered distribution of oil to the various bearings is effected by use of Bijur "Meter-Units." A single line of tubing leads from the pump, and junction fittings permit branching at any point to suit the layout of the machine. The lubricator measures approximately 2x3½x 3½ in. Piston stroke, which is adjustable, may be set to give a total oil delivery of from 2 to 30 drops as desired



for each particular type of machine. Bijur Lubricating Corp., Long Island City, N. Y.

Shock-Resistant Plastic

A phenolic molding material with five times greater impact strength than standard molding materials. Known as Durez 1590, the material has an impact strength of 0.7 (A.S.T.M.) and should find many industrial applications where greater resistance to shock is desired. Molds and performs easily, has a relatively low bulk factor and in molded form has a somewhat rippled surface, which can be minimized by ribbing or engraving in the mold on decorative pieces. General Plastics, Inc., North Tonawanda, N. Y.

Totally-Inclosed Fan-Cooled Motor

Recently improved Type CP, consisting of a skeleton type stator, grooved on the outside to increase radiation. Totally-inclosed ball bearing endplates completely seal the working parts of the unit. An external blower mounted on the front and directs cooling air around the front endplate and over the corrugated surfaces and through a baffled back endplate down over the bearing.

Ball bearings are of the cartridge type, the front end bearing carrying the thrust while the back bearing is of the floating self-aligning type. Endplates and rotor can be reversed to reverse location of conduit box. Designed especially for operation in atmospheres heavily laden with abrasive dusts, explosive dusts, corrosive gases or extreme dampness. Wagner Electric Corp., Plymouth Ave., St. Louis, Mo.

"Mushroom" Head Pushbutton Station

Although developed primarily for use in bakeries where it is important that dough from the operator's hands does not work into the station to interfere with operation, this new station is also particularly suitable for use on machines where it is necessary for the operator to wear heavy gloves or asbestos mittens.

A slap of the open hand on the "mushroom" head is sufficient to stop a machine controlled by the device. Essentially, the pushbutton is of the same general construction as the standard General Electric heavy-duty pushbutton station except that, in the case of the new station, the molded "stop" button, to which the mushroom head is fitted, is approximately ½ in. longer than the "stop" button on standard equipment. The mushroom head is screwed to a metal insert in the end of the button. The new station is also available without the mushroom head and with the insert undrilled so that it can be used in applications which require an extended button of the ordinary type. General Electric Co., Schenectady, N. Y.

Manufacturers' Publications

BEARING LAYOUTS—New Departure Div. of General Motors Corp., Bristol, Conn. Form No. 205, 9x12 in. Set of 19 sheets containing full-size drawings of ball bearings for layout work. Single row, double row, radax, duplex and self-sealed bearings are included in a complete range of sizes for all series.

BELT DRIVES—Alexander Brothers, Inc., 406 N. Third St., Philadelphia, Pa. Catalog A-117, 32 pages, 8½x11. Complete technical data on the "Tentacular" transmission belt. Charts and tables on belt speeds, horsepower ratings, prices, etc., are included, together with illustrations of typical Tentacular belt applications.

"CATERPILLAR" PRODUCTS — Caterpillar Tractor Co., Peoria, Ill. Booklet, No. 4198, 32 pages, 8¼x10¾ in. "On Construction Jobs with 'Caterpillar' Products," a pictorial record of the various types of construction jobs for which "Caterpillar" tractors, road machinery and engines are suited.

CORROSION-RESISTING EQUIPMENT — The Duriron Co., Inc., Dayton, Ohio. General Catalog 1937-38, 12 pages, 8¼x11 in. Illustrating and describing corrosion-resistant process equipment for the economical handling of corrosive solutions.

ENAMELS—Roxalin Flexible Lacquer Co., Elizabeth, N. J. 2 folders, 9x11 in. Product summaries giving the properties of the following cellulose type, air-drying, flexible lacquer enamels: extra-smooth leafing aluminum "Blue Knight Leaflex 5900" and chip-proof black and colored "Blue Knight Blax."

FINISH—Hilo Varnish Corp., 42-60 Stewart Ave., Brooklyn, N. Y. Bulletin 9-HK, loose-leaf insert, 5x7½ in. Latest information on "Hammerkraft," a new finish giving the effect of hammered metal. Discusses method of application, color combinations and illustrates two typical effects.

FLEXIBLE COUPLINGS—The Falk Corp., Milwaukee, Wis. Bulletin 4100 (Supersedes 181 and 182), 36 pages, 8½x11 in. Covers specification, design, rating, method of selection and dimensions of "Steelflax" couplings, including the FA series available in ratings from 0.4 hp. to 18,000 hp. A section is also devoted to installation pictures.

FLEXIBLE METAL HOSE — Chicago Metal Hose Corp., Maywood, Ill. Catalog, 26 pages, 8½x11 in. Covering annular corrugation "Rex-Weld" and spiral wound "Rex-Tube" flexible metal hose. Latest developments in tubing design and construction, technical data on its uses and illustrated applications are included.

FLUORESCENT MATERIALS—Callite Products Co., 550 39th St., Union City, N. J. Bulletin, 8½x11 in. Notes on fluorescent and phosphorescent bodies with a discussion of materials that can be used with cathode ray, ultra violet, x-ray and visible light excitation, also descriptions of ultra violet industrial and laboratory generators.

FRICTION CLUTCHES—The Carlyle Johnson Machine Co., Manchester, Conn. Folder, 6x9 in. Descriptive data and revised price lists and sizes on their line of Johnson friction clutches, to which has been added three new models, including a "midget type" clutch for fractional horsepower drives.

"HANDBOOK OF COMMON MACHINE FASTENERS"—Russell, Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y. Booklet, 7½x3 in. 20 pages. Showing 26 illustrations of the latest accepted standard methods of drawing various types of bolts, nuts and rivets.

HUB SPROCKETS — Balwin-Duckworth Chain Corp., Springfield, Mass. Bulletin 60, 24 pages, 8½x11 in. Listing dimensions and prices of standard hub sprockets for single, double and triple roller chains.

METALGRAM—Apex Smelting Co., 2554 Fillmore St., Chicago, Ill. Data Sheet No. 21, 4 pages, 8½x11 in. Presenting a summary of the results of tests of the four major physical properties of zinc base die-cast alloy No. 6 when cast under the controlled variables employed by Apex.

METAL TRIM—American Nickeloid Co., 30 Second St., Peru, Ill. Leaflet, 9x12 in. Showing some typical applications of nickel steel and chrome steel round edge flat wire on home appliances for improved appearance.

MOTORS—Century Electric Co., 1806 Pine St., St. Louis, Mo. Form 1032, 8 pages, 8x10½ in. Illustrating and describing their slip-ring induction polyphase motors of 1 to 350 hp. for such applications as fans and blowers, hoists, conveyors, pumps, elevators, printing presses, stokers, etc.

NEOPRENE—E. I. duPont de Nemours & Co., Wilmington, Del. Bulletin, 24 pages, 6x9 in. Presents a detailed description of the material, its advantages for certain types of service and specific applications. A summary of the method of making Neoprene and its chemical composition are included.

OIL SEALS—Victor Mfg. & Gasket Co., 5752 Roosevelt Rd., Chicago, Ill. Catalog No. 301, 20 pages, 8½x11 in. Data on Victoprene oil seals with complete listing of sizes available. Striking pictures showing how the seals are made and tested and the types available are included.

OPTIMATIC SYSTEM — The Brown Instrument Co., Wayne & Roberts Aves., Philadelphia, Pa. Bulletin No. 91-1, 20 pages, 8x10½ in. Describes and illustrates the Brown Optimatic System, an automatic optical pyrometer for measuring surface temperatures of hot bodies in motion or at rest. Details of operation, constructional features and applications are included.

PAINT—Metalead Products Corp., Balfour Bldg., San Francisco, Calif. Leaflet 3½x9 in. Describing a new patented metallic lead pigment used with suitable vehicles for painting surfaces to be protected against various corrosion conditions by forming a thin protective sheet of pure lead on the surface that has been painted.

PLASTIC MOLDING—Chicago Molded Products, Inc., 2145-58 Walnut St., Chicago, Ill. Booklet, 40 pages, 6x9 in. The contents of this booklet, "The Story of Plastic Molding," includes an article on molds and how they are used, an explanation of the factors which determine price, a description of the various molding materials and their properties, hints on design, and a comprehensive listing of parts available from stock molds.

PULLEYS AND FLEXIBLE COUPLINGS—The Congress Tool & Die Co., Inc., 9030 Lumpkin Ave., Detroit, Mich. Folder, 8½x11 in. Complete listing of their line of V-grooved pulleys, variable-speed pulleys, step-cone pulleys and flexible couplings.

PULLMORE CLUTCHES—Rockford Drilling Machine Div., Borg-Warner Corp., 113 Catherine St., Rockford, Ill. Booklet, 22 pages, 4x9 in. Well illustrated, descriptive data on Pullmore multiple disk clutches including specifications, dimensional drawings and numerous application pictures.

REVERE ALLOYS—Revere Copper and Brass Incorporated, 230 Park Ave., New York, N. Y. Data Sheet, 8½x11 in. Covering the chemical and physical properties of Revere alloys.

SMOOTHARC WELDERS — Harnischfeger Corp., Milwaukee, Wis. Bulletin No. W10, "The Arc-Welding of Tomorrow." Presents the advantages gained by the internally stabilized arc and explains its importance in modern welding. Design details and many action pictures illustrating the uses of the Smootharc welders are included.

STAINLESS STEEL—The American Rolling Mill Co., Middletown, Ohio. Booklet, 26 pages. "Armco Stainless Steels—Chromium Nickel Grades," contains detailed information on heat-treatment, drawing, punching and shearing, spinning, riveting, welding, electric and gas welding, soldering, brazing and pickling. Includes illustrations showing the uses of Armco stainless steels, charts showing chemical and physical properties and corrosion resistance data.

"THE HOSE SPECIALISTS"—Elctric Hose & Rubber Co., Wilmington, Del. Loose-leaf pocket size catalog, 64 pages. Data and information covering their complete line of braided and molded hose, conveniently indexed according to uses as well as types.

TIME CONTROLS—Automatic Temperature Control Co., Inc., 34 East Logan St., Philadelphia, Pa. Bulletin G-14, 4 pages, 8½x11 in. Showing some interesting types of automatic timers involving the design of special equipment where standard timers could not handle the application.

WATTHOUR METERS — General Electric Co., Schenectady, N. Y. Bulletin GEA-2404A, 16 pages, 8x10½ in. Complete data on their two-element, single-disk V-type watthour meters, including installations, specifications and schematic connection diagrams.

WELDING CHART—The Lincoln Electric Co., Cleveland, Ohio. 24x35½ in. high, suitable for hanging on the wall. Contains weld symbols for working drawings together with instructions for their use. Also includes nomenclature for different types of welding, types of electrode metal for hard facing, properties of weld metals and base metals, typical joints for arc welding, safe allowable loads for fillet welds and similar data.

"WELDING OF ENDURO STAINLESS STEEL"—Republic Steel Corp., Cleveland, Ohio. Booklet Adv. 180, 20 pages. Well illustrated booklet describing in detail the proper methods for welding stainless steel by electric arc, gas, seam, spot, projection and atomic hydrogen methods. Also contains information on brazing and silver soldering. A table showing in condensed form the physical, electrical and mechanical properties of 13 of the more important types of Enduro stainless steel contrasted with similar properties of a carbon steel, S.A.E. 1020 is included.

Books and Bulletins

Procedure Handbook of Arc Welding Design and Practice

REPRINTED FOURTH EDITION. *839 pages, over 1,000 illustrations. Published by The Lincoln Electric Co., Cleveland, Ohio. Price $1.50 in U.S.A.*

An enlarged reprinted fourth edition of the arc welding handbook containing important new information for the arc welding industry. Additional material includes 16 pages of the latest weld symbols recently adopted by the American Welding Society, and a new introduction to Section VI devoted to designing for arc welded steel construction of machinery emphasizing the fundamental principles which the designer should keep in mind in approaching the problem of redesigning for arc welded construction.

The complete handbook is divided into 8 sections: (1) welding methods and equipment, (2) technique of welding, (3) procedure, speeds and costs for welding mild steel, (4) structure and properties of weld metal, (5) weldability of metals, (6) designing of arc welded steel construction of machinery, (7) designing for arc welded structures, (8) typical applications in manufacturing, construction and maintenance.

Vanadium Steels and Irons

189 pages, 6¼x9¼ in. Flexible leatherette covers. Published by the Vanadium Corporation of America, 420 Lexington Ave., New York, N. Y. Price $1.25, but available without charge to executives and engineers engaged in using or specifying alloy steels and irons.

A handbook of applied metallurgy written for metallurgists, designing engineers and others interested in the production, fabrication and use of metals. It presents authentic and concise information concerning the properties of ferrous alloys containing vanadium, and their numerous applications.

Structural steels for light and heavy sections, the familiar S.A.E. alloy and related high-test steels, spring steels, cast steels, tool steels and nitriding steels are treated comprehensively, with complete data on physical properties and heat-treatment. In each case, conditions under which most favorable service results can be expected are specifically outlined and suggestions are made for correlating the choice of alloy steel and its heat-treatment with the fabricating procedure to be used. A special chapter is devoted to consideration of high-test alloy cast irons, a field in which considerable progress has recently been made.

The handbook is illustrated with 71 photomicrographs and 178 charts and tables, is well indexed for quick reference, and includes bibliographic references under each chapter.

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Tin Research

Recent report published by the International Tin Research and Development Council. Copies are available free from L. J. Tavener, 149 Broadway, New York, N. Y.

"The Use of Tin in Refrigerating Equipment," by E. J. Daniels and D. J. Macnaughtan, Series B, No. 3, 8 pages.

Design of Welded Piping

THE LINDE AIR PRODUCTS CO., *30 East 42d St., New York, N. Y. 200 pages, 6x9 in. Paper covers. Over 100 figures and tables.*

A complete handbook containing essential information on all design phases of welded piping. Subjects treated of interest to engineers are fundamentals of welded joint design; welding metallurgy; standard welded pipe connections; design data on welding cast iron, galvanized iron, stainless steel and non-ferrous piping; advantageous layout; fabrication and erection considerations; welded anchors and supports; and welding speeds.

PRODUCT ENGINEERING + REFERENCE BOOK SHEET

Formulas for Circular Rings

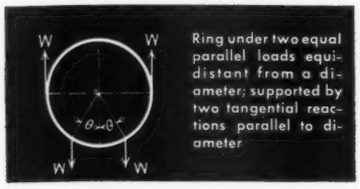
RAYMOND J. ROARK
Professor of Mechanics, University of Wisconsin

(Continued from page 288, July issue)

LOADING AND SUPPORT

Bending moment M, circumferential tension T, radial shear V at angular distance X from bottom of ring and for D_x change in horizontal diam., and D_y change in vertical diam.

7



Ring under two equal parallel loads equidistant from a diameter; supported by two tangential reactions parallel to diameter

$(X=0 \text{ to } X=\theta),\ M=WR\left[0.3183\ (UC^2-S\,\theta-C)+S-\frac{1}{2}\right]$

$(X=0 \text{ to } X=\theta),\ T=W\ (0.3183\ UC^2)$

$(X=0 \text{ to } X=\theta),\ V=-W\ (0.3183\ ZC^2)$

$Dx=\frac{WR^3}{EI}\left[\frac{1}{2}\,(S^2+1)-0.6366\ (S\,\theta+C)\right]$

$(X=\theta \text{ to } X=\pi/2),\ M=WR\left[0.3183\ (UC^2-S\,\theta-C)+Z-\frac{1}{2}\right]$

$(X=\theta \text{ to } X=\pi/2),\ T=W\ (0.3183\ UC^2+Z)$

$(X=\theta \text{ to } X=\pi/2),\ V=W\ (U-0.3183\ ZC^2)$

$(X=\pi/2 \text{ to } X=\pi),\ M=WR\left[0.3183\ (UC^2-S\,\theta-C)+\frac{1}{2}\right]$

$(X=\pi/2 \text{ to } X=\pi),\ T=W\ (0.3183\ UC^2)$

$(X=\pi/2 \text{ to } X=\pi),\ V=-W\ (0.3183\ ZC^2)$

$D_y=\frac{WR^3}{EI}\left[S-\frac{1}{2}\,(SC+\theta)-0.6366\ (S\,\theta+C)+0.7854\right]$

8

Ring under any two equal, parallel loads equidistant from a diameter; supported by any two reactions parallel to and equidistant from the diameter

$(X=0 \text{ to } X=\theta)\ M=WR\ [0.3183\ (N\theta+H-S\theta-C-US^2+UN^2)-N+S]$

$(X=0 \text{ to } X=\theta)\ T=W\ [0.3183\ U\ (N^2-S^2)]$

$(X=0 \text{ to } X=\theta)\ V=W\ [0.3183\ Z\ (S^2-N^2)]$

$(X=\theta \text{ to } X=\phi)\ M=WR\ [0.3183\ (N\phi+H-S\theta-C-US^2+UN^2)-N+Z]$

$(X=\theta \text{ to } X=\phi)\ T=W\ [0.3183\ U\ (N^2-S^2)+Z]$

$(X=\theta \text{ to } X=\phi)\ V=W\ [0.3183\ Z\ (S^2-N^2)+U]$

$(X=\phi \text{ to } X=\pi)\ M=WR\ [0.3183\ (N\phi+H-S\theta-C-US^2+UN^2)]$

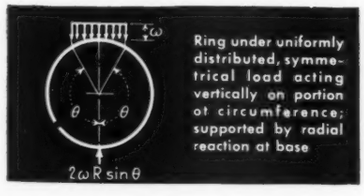
$(X=\phi \text{ to } X=\pi)\ T=W\ [0.3183\ U\ (N^2-S^2)]$

$(X=\phi \text{ to } X=\pi)\ V=W\ [0.3183\ Z\ (S^2-N^2)]$

$D_x=\frac{WR^3}{EI}\left[\frac{1}{2}\,(S^2+N^2)+0.6366\ (N\phi+H-S\theta-C)+1-2N\right]$

$D_y=\frac{WR^3}{EI}\left[\frac{1}{2}\,(NH+\phi-SC-\theta)+0.6366\ (N\phi+H-S\theta-C)+S-N\right]$

9



Ring under uniformly distributed, symmetrical load acting vertically on portion of circumference; supported by radial reaction at base

$M_1=wR^2\left[\frac{1}{4}+\frac{1}{2}\,S^2+0.3183\ (S-\frac{1}{2}\,\theta S^2-\frac{1}{3}\,S^3-\frac{3}{4}\,SC-\frac{1}{4}\,\theta)\right]$

$T_1=-0.1061\ w\,R\,S^2$

$(X=0 \text{ to } X=\theta)\ M=M_1-wR^2\ [SZ+0.1061\ S^3\ (1-U)]$

$(X=0 \text{ to } X=\theta)\ T=-wR\ (0.1061\ S^3U+SZ)$

$(X=0 \text{ to } X=\theta)\ V=wR\ (0.1061\ S^2Z-SU)$

$(X=\theta \text{ to } X=\pi)\ M=M_1-wR^2\ [0.1061\ S^3\ (1-U)-\frac{1}{2}\,(S^2+Z^2)]$

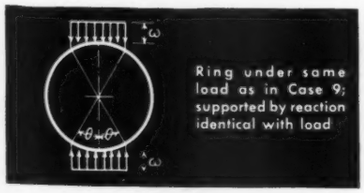
$(X=\theta \text{ to } X=\pi)\ T=-wR\ (0.1061\ S^3U+Z^2)$

$(X=\theta \text{ to } X=\pi)\ V=wR\ (0.1061\ S^2Z-ZU)$

$D_x=\frac{2wR^4}{EI}\left[\frac{1}{4}+\frac{1}{2}\,S^2-\frac{1}{12}\,S^3-0.3183\ (\frac{1}{4}\,\theta+\frac{3}{4}\,SC+\frac{1}{2}\,\theta S^2-S)\right]$

$D_y=\frac{2wR^4}{EI}\left[\frac{1}{12}+\frac{1}{4}\,S^2-\frac{1}{12}\,S^2C-\frac{1}{4}\,\theta S-\frac{1}{6}\,C-0.3183\ (\frac{1}{2}\,\theta S^2+\frac{3}{4}\,SC+\frac{1}{4}\,\theta-S)\right]$

10



Ring under same load as in Case 9; supported by reaction identical with load

$M_1=wR^2\left[0.3183\ (\frac{1}{2}\,\theta+\theta S^2+\frac{3}{2}\,SC)-\frac{1}{2}\,S^2\right]$

$T_1=0$

$(X=0 \text{ to } X=\theta)\ M=M_1-wR^2\ (\frac{1}{2}\,Z^2)$

$(X=\theta \text{ to } X=\pi-\theta)\ M=M_1-wR^2\ (SZ-\frac{1}{2}\,S^2)$

$(X=0 \text{ to } X=\theta)\ T=-wRZ^2$

$(X=\theta \text{ to } X=\pi-\theta)\ T=-wRSZ$

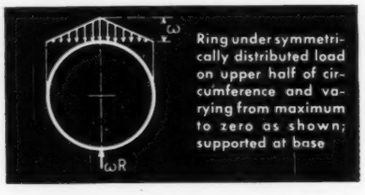
$(X=0 \text{ to } X=\theta)\ V=-wRZU$

$(X=\theta \text{ to } X=\pi-\theta)\ V=-wRSU$

$D_x=\frac{wR^4}{EI}\left[1+2\,S^2-\frac{1}{12}\,S^3+S-0.3183\ (\theta+3\,SC+2\,\theta S^2)\right]$

$D_y=\frac{wR^4}{EI}\left[S^2-\frac{1}{3}\,S^2C-\theta S-\frac{2}{3}\,C+\frac{1}{3}+\frac{1}{2}\,\pi S-0.3183\ (2\,\theta S^2+3\,SC+\theta)\right]$

11



Ring under symmetrically distributed load on upper half of circumference and varying from maximum to zero as shown; supported at base

$M_1 = 0.305\, w\, R^2$; $\quad T_1 = -\,w\,R\,(0.02653)$

$(X=0 \text{ to } X=\pi/2)\quad M = M_1 - T_1 R\,(1-U) - \frac{1}{2}\,w\,R^2 Z$

$(X=0 \text{ to } X=\pi/2)\quad T = T_1\,U - \frac{1}{2}\,w\,R\,Z$

$(X=0 \text{ to } X=\pi/2)\quad V = -\,T_1 Z - \frac{1}{2}\,w\,R\,U$

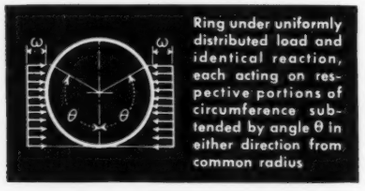
$(X=\pi/2 \text{ to } X=\pi)\quad M = M_1 - T_1 R\,(1-U) - \frac{1}{2}\,w\,R^2 Z - \frac{1}{6}\,w\,R^2\,(1-Z)^3$

$(X=\pi/2 \text{ to } X=\pi)\quad V = -\,T_1 Z - \frac{1}{2}\,w\,R\,U + \frac{1}{2}\,w\,R\,(1-Z)^2\,U$

$(X=\pi/2 \text{ to } X=\pi)\quad T = T_1\,U - \frac{1}{2}\,WRZ + \frac{1}{2}\,wR\,(1-Z)^2 Z$

$D_x = +\dfrac{0.1228\,w\,R^4}{EI}$ $\qquad$ $D_y = -\dfrac{0.1220\,w\,R^4}{EI}$

12



Ring under uniformly distributed load and identical reaction, each acting on respective portions of circumference subtended by angle θ in either direction from common radius

$M_1 = wR^2\left[0.3183\,(\frac{2}{3}\,S - \theta C + \frac{1}{3}\,SC^2 + \frac{1}{2}\,\theta C^2 - \frac{3}{4}\,SC + \frac{1}{4}\,\theta) - \frac{1}{2} + C - \frac{1}{2}\,C^2\right]$

$T_1 = wR\,[0.3183\,(\frac{2}{3}\,S + \frac{1}{3}\,SC^2 - \theta C) + C - 1]$

$(X=\theta \text{ to } X=\pi)\quad M = M_1 - T_1 R\,(1-U) - \frac{1}{2} wR^3\,(1-C)\,(1+C-2\,U)$

$(X=0 \text{ to } X=\theta)\quad M = M_1 - T_1 R\,(1-U) - \frac{1}{2}\,wR^2\,(1-U)^2$

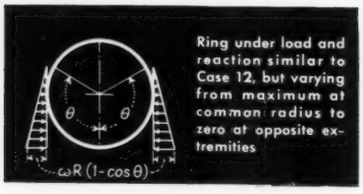
$(X=\theta \text{ to } X=\pi)\quad T = T_1\,U + w\,R\,(1-C)\,U$

$(X=0 \text{ to } X=\theta)\quad T = T_1\,U + w\,R\,(1-U)\,U$

$(X=\theta \text{ to } X=\pi)\quad V = -\,T_1 Z - w\,R\,(1-C)Z$

$(X=0 \text{ to } X=\theta)\quad V = -\,T_1 Z - w\,R\,(1-U)Z$

13



Ring under load and reaction similar to Case 12, but varying from maximum at common radius to zero at opposite extremities

$M_1 = wR^2\left[0.3183(\frac{1}{8}\,\theta + \frac{1}{9}\,S - \frac{1}{4}\,\theta C - \frac{13}{24}\,SC + \frac{11}{36}\,SC^2 + \frac{1}{2}\,\theta C^2 - \frac{1}{12}\,SC^3 - \frac{1}{6}\,\theta C^3) - \frac{1}{6}\,(1-C)^3\right]$

$T_1 = w\,R^2\left[0.3183\,(\frac{1}{8}\,\theta + \frac{1}{2}\,\theta C^2 - \frac{13}{24}\,SC - \frac{1}{12}\,SC^3) - \frac{1}{2}\,(1-C)^3\right]$

$(X=0 \text{ to } X=\theta)\quad M = M_1 - T_1 R\,(1-C) + w\,R^3\left[\frac{1}{6}\,(1-U)^3 - \frac{1}{2}\,(1-C)\,(1-U)\right]$

$(X=\theta \text{ to } X=\pi)\quad M = M_1 - T_1 R\,(1-C) + w\,R^3\left[\frac{1}{2}\,(1-C)^2\,(\frac{1}{3} + \frac{2}{3}\,C - U)\right]$

$(X=0 \text{ to } X=\theta)\quad T = T_1\,U + w\,R^2\left[\frac{1}{2}\,(1-2\,C+U)\,(1-U)\,U\right]$

$(X=\theta \text{ to } X=\pi)\quad T = T_1\,U + w\,R^2\left[\frac{1}{2}\,U\,(1-C)^2\right]$

$(X=0 \text{ to } X=\theta)\quad V = -\,T_1 Z - w\,R^2\left[\frac{1}{2}\,(1-2\,C+U)\,(1-U)Z\right]$

$(X=\theta \text{ to } X=\pi)\quad V = -\,T_1 Z - w\,R^2\left[\frac{1}{2}\,Z\,(1-C)^2\right]$

14

Ring under radial load; supported by uniformly distributed, symmetrical load acting radially

$M_1 = w\,R^2\,[C - 0.3183\,(\theta\,C - \theta) - 1]$ $\qquad$ $T_1 = w\,R\,[0.3183\,(S - \theta C) + C - 1]$

$(X=0 \text{ to } X=\theta)\quad M = M_1 - T_1 R\,(1-U) - w\,R^2\,(1-U-SZ)$

$(X=0 \text{ to } X=\theta)\quad T = T_1\,U + w\,R\,(SZ + U - 1)$

$(X=0 \text{ to } X=\theta)\quad V = -\,T_1 Z + w\,R\,(S\,U - Z)$

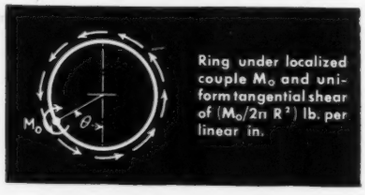
$(X=\theta \text{ to } X=\pi)\quad M = M_1 - T_1 R\,(1-U) - w\,R^2\,(C\,U - U)$

$(X=\theta \text{ to } X=\pi)\quad T = T_1\,U + w\,R\,(U - C\,U)$

$(X=\theta \text{ to } X=\pi)\quad V = -\,T_1 Z + w\,R\,(CZ - Z)$

$D_x = \dfrac{2\,wR^4}{EI}\left[\frac{1}{4}\,\theta C + 0.3183\,\theta - 0.5683 S\right]$ when $\theta < \pi/2$ $\qquad$ $D_y = \dfrac{2\,wR^4}{EI}\left[\frac{1}{4}\,\theta S + 0.3183\,\theta + \frac{1}{2}\,C - 1.6817\,S - \frac{1}{2}\right]$

15



Ring under localized couple M_o and uniform tangential shear of $(M_o/2\pi R^2)$ lb. per linear in.

$(X=0 \text{ to } X=\theta)\quad M = M_o\left[0.3183\,(US - ZC + \frac{1}{2}\,\theta - \frac{1}{2}\,X) - \frac{1}{2}\right]$

$(X=0 \text{ to } X=\theta)\quad T = -\dfrac{M_o}{R}\left[0.3183\,(ZC - US)\right]$

$(X=0 \text{ to } X=\theta)\quad V = -\dfrac{M_o}{R}\left[0.3183\,(ZS + UC + \frac{1}{2})\right]$

$(X=\theta \text{ to } X=2\pi)\quad M = M_o\left[0.3183\,(US - ZC + \frac{1}{2}\,\theta - \frac{1}{2}\,X) + \frac{1}{2}\right]$

$(X=\theta \text{ to } X=2\pi)\quad T = -\dfrac{M_o}{R}\left[0.3183\,(ZC - US)\right]$

$(X=\theta \text{ to } X=2\pi)\quad V = -\dfrac{M_o}{R}\left[0.3183\,(ZS + UC + \frac{1}{2})\right]$

(Continued in September issue)